Optimal Progressive Income Taxation and Endogenous Marriage and Divorce

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Motivation

- The optimal degree of income tax progressivity has been a central issue in policy making.
  - provide social insurance against uninsurable idiosyncratic earning risks
  - most of the works are done with single-earner households.
- In U.S., income tax unit is a households, not an individual
  - higher marginal tax rate on the secondary earners impacts their labor supply patterns.
  - they are typically wives, and their labor supplies are more elastic.
  - differential tax burdens across marital status.
  - rewards asymmetric earning couples, penalties on symmetric earning couples

What This Paper Does

- Construct a model in which both single and married households exist and income taxes affect
  - the secondary earner labor supply patterns
  - allocations/divorce decisions of married couples
  - household formation decisions of singles
- Estimate parameters that mimic individual's marriage/divorce and labor supply patterns.
- Compute the welfare-maximizing income tax progressivity when married households can file jointly

Modeling Married Households

- We model the negotiation process of married households with a NEW approach
- Unitary model or collective model with commitment
  - allocation rule is fixed (outside option values are not reflected to the allocation)
  - divorce is an exogenous shock
- Collective model with limited-commitment:
  - adjust decision weight when one of the incentive constraints binds (higher outside value trigger updates)
  - decision weight is a state variable (non-Markovian)
  - all the surplus from the match goes to the one with slack constraint (relatively low outside value)

Modeling Married Households

- We model the negotiation process of married households with a NEW approach
- In our approach, married households decide the current period allocation/divorce through the negotiation every period
  - Pareto weight is no longer a state variable (Markovian)
  - trade-off between demanding more favorable deals and the risk of divorce
  - spouses split the surplus from match
- Resulting allocation is still on the Pareto frontier
- Improvement of outside value may result in better allocations by larger Pareto weight

Empirical Evidence of Effects of Tax reform on Marriage

- Marriage rate and decisions (Alm and Whittington (1995), Alm and Whittington (1999))
  - the percentage of married female 15-44 on difference of tax burdens
  - marriage-tax elasticity is statistically significant, but is less than -0.05 (1% increase by 20% tax fall)
  - however, the elasticity of marriage w.r.t. the marriage penalty is -1.25 at the extreme penalty
- Marriage decisions (Alm and Whittington (1997))
  - delay of marriage decisions on changes in income tax burden upon marriage
  - if the average marriage penalty to a couple doubles, a couple delays marriage by around 1%.

Mechanism: Joint to separate filing example

- Current U.S. income tax rewards asymmetric earnings couples
- Consider one with high earning,
  - marriage bonus if married with (i) a low earnings potential, or (ii) a high earning potential but not working
  - with such a spouse, the head of household enjoys lower marginal tax rate.
- If eliminate joint filing,
  - Marriage bonus disappears $\rightarrow$ less picky in marriage match.
  - Higher marginal tax rate for the head of household (work less)
  - Lower marginal tax rate for the spouse (work more $\rightarrow$ higher outside value).

Literature

- Progressive income taxation with two-earner households
  - Kleven et al. (2009), Guner et al. (2012), Gayle and Shephard (2019), Siassi (2019), Obermeier (2019), Wu and Krueger (2021), Leung (2019), Holter et al. (2019)
  - My Contribution: Tax reforms affect household formation/dissolution and the marital sorting pattern in a dynamic general equilibrium model
- Taxes and female labor supply
  - Keane (2011), Blundell et al. (2016a), Kaygusuz (2010), Crossley and Jeon (2007), Bosworth and Burtless (1992), Triest (1990), Eissa (1995)
  - My Contribution: allow interaction between labor supply pattern changes and intra-household decision power
- Taxes and marriage patterns
  - Alm and Whittington(1995,1997,1999), Chade and Ventura (2002), Chade and Ventura (2005), Frankel (2014)
  - My Contribution: quantify impacts of income tax reform on sorting pattern, marriage and divorce, and labor supply patterns in a dynamic model

What The Paper Finds

- In case of separate filing (no possibility of joint filing)
  - number of married households +3%, Frac. same education couples -1%
  - marriage neutral tax $\rightarrow$ more likely to accept the spouse in the marriage pool
  - Married females: hours work (+4%), employment rates (+5%) with lower marginal tax rate
- The optimal degree of income tax progressivity is higher than the current U.S. system
  - number of married households +2%, Frac. same education couples +2%
  - larger marriage bonuses makes asymmetric earning marriage better
  - division of labor and non-economic benefit link the similar earning potentials
  - Married females: hours work (-2%), employment rates (-2%) with higher marginal tax rate

Model

Demographics

- Overlapping generation model. Agents are indexed by
  - age: $j \in \{1, \ldots, J\}$, sex: $g \in \{m, f\}$, education: $e \in \{nc, co\}$, time-variant productivity: $z \in \mathcal{Z}$, children: $d \in \{0, 1\}$, asset: $a \in [0, \overline{A}]$
- Individuals can form either a single or a married household with a spouse.
- Upon divorce, assets are split equally and children belong to females.
- Fertility is an exogenous event, but the arrival rates depend on marital status, and education if single.
- Children affects (i) home good production, (ii) childcare cost, (iii) return from leisure

Preference and Time Allocation

- Agents enjoy consumption, leisure, and home production goods, $u(c, \ell, Q)$
  - For married individuals, c and ℓ are private goods, Q is public within a couple.
- They can choose time allocation across leisure ℓ, market work n, and house work h from the discrete choice set $(\ell, n, h) \in \mathcal{T}$.
- Q is produced by house work (h)

Timeline within a period

- Learn fertility and labor productivity shocks.
- Marriage pool or Negotiation
  1. singles go to the marriage pool and randomly meet with a potential spouse
  2. married couples decide the current period Pareto weight/divorce.
- Solve the decision problem. Married couples' decisions depend on the current period Pareto weight.

End-of-period Problem: Single Working-age Household

- Solve consumption and saving problem conditional on the time allocation $t \in \mathcal{T}$
- If no childcare cost

$$\max_{c,a' \geq 0} u(c, \ell, Q) + \beta E \widetilde{V}^g(a', s')$$
$$\text{s.t. } (1 + \tau_c)c + a' = y - \tau^{\mathcal{S}}(y) + a$$

- taxable income $y = \widehat{w}(s)n + ra$

▸ Full Decision Problem

End-of-period Problem: Single Working-age Household

- Solve consumption and saving problem conditional on the time allocation $t \in \mathcal{T}$
- If pays childcare cost

$$\max_{c,a' \geq 0} u(c, \ell, Q) + \beta E \widetilde{V}^g(a', s')$$
$$\text{s.t. } (1 + \tau_c)c + a' = y - \tau^{\mathcal{S}}(y) + a \underbrace{- \widehat{w}(s)\chi n}_{\text{childcare cost}}$$

- taxable income $y = \widehat{w}(s)n + ra$

▸ Full Decision Problem

End-of-period Problem: Married Working-age Household

- Conditional on $\mathbf{t} \in \mathcal{T} \times \mathcal{T}$, with no childcare cost

$$\max_{c^f, c^m, a' \geq 0} \lambda \Big[u(c^f, \ell^f, Q) + \beta E \widetilde{W}^f(a', \mathbf{s}') \Big] + (1 - \lambda) \Big[u(c^m, \ell^m, Q) + \beta E \widetilde{W}^m(a', \mathbf{s}') \Big]$$
$$\text{s.t. } (1 + \tau_c)(c^f + c^m) + a' = y - \tau^M(y) + a$$

- taxable income $y = \widehat{w}^m(s^m) h^m + \widehat{w}^f(s^f) h^f + ra$

- Negotiation pins down the current period Pareto weight (λ not a state variable)

▸ Full Decision Problem

End-of-period Problem: Married Working-age Household

- Conditional on $\mathbf{t} \in \mathcal{T} \times \mathcal{T}$, if pays childcare cost

$$\max_{c^f, c^m, a' \geq 0} \lambda \Big[u(c^f, \ell^f, Q) + \beta E \widetilde{W}^f(a', \mathbf{s}') \Big] + (1-\lambda) \Big[u(c^m, \ell^m, Q) + \beta E \widetilde{W}^m(a', \mathbf{s}') \Big]$$
$$\text{s.t. } (1+\tau_c)(c^f + c^m) + a' = y - \tau^M(y) + a - \widehat{w}^f(s^f)\chi n^f$$

- taxable income $y = \widehat{w}^m(s^m)h^m + \widehat{w}^f(s^f)h^f + ra$

- Negotiation pins down the current period Pareto weight (λ not a state variable)

▸ Full Decision Problem

Start-of-Period Problem: Single Working-age Household

- When a single working-age female enters the marriage pool, she
  1. meets a mate with probability p_j
     - Marriage: both agree to form a married household
     - No marriage: at least one decline the proposal (bilateral)
  2. cannot find a potential spouse $(1 - p_j)$

- Start-of-period expected value $E\widetilde{V}^f(a^f, s^f)$ depends on
  - distribution of single men
  - errors to the values of each marital status

▸ Value at Marriage Pool

Start-of-Period Problem: Married Working-age Household

- Taxes affect intra-household allocations
  - Pareto weight reflects the outside values, relative size of income earned, and the efficiency of home productions
- In the standard approach in limited commitment model
  - minimal adjustment of Pareto weight only when one of the incentive constraint binds
  - all the surplus from the match goes to the one with slack incentive constraint
- Following Kato and Ríos-Rull (2021)
  - married couples decide allocations/divorce by negotiation every period (make λ not a state variable)
  - demanding is costly; higher Pareto weight may result in a more favorable allocation, but also increases the risk of divorce

▸ Negotiation Details

Start-of-Period Problem: Married Working-age Household

- Potentially two-stage game
  1. Choose *Satisfied (S)* or *Challenge (C)*
     - If both choose S, set $\lambda = \lambda^{SS}$ and stay married
     - If both choose C, get divorce.
     - If one of them chooses C, go to the next stage.
  2. The one who chooses C offer new λ, and the other decides whether accept or reject (=divorce) it

- *Challenge* and high λ offer may result in better allocations for the Challenger, but it also increases the risk of being rejected and divorce.

- Start-of-period expected value $E\widetilde{W}$ depends on the expected value from choosing *Satisfied* and *Challenge*

▸ Negotiation Details ▸ Value at Negotiation Stage

Parameterization and Estimation

Preference

- Following Shephard (2019), per-period utility function:

$$u^g(c, \ell, Q) = \frac{c^{1-\sigma} \exp\left[(1-\sigma)(v_g(\ell) + \beta_Q Q^{1-\sigma_Q}/(1-\sigma_Q))\right]}{1-\sigma}$$

- Following Benabou (2002) and Guner et al. (2014), income tax amount paid by households are

$$\tau(y) = (1 - \tau \widetilde{y}^{-\kappa})y$$

- where $\widetilde{y}$ is a multiple of mean household income, and (τ, κ) differs across marital status.

- Home production functions

$$Q^S(h, d) = \eta_d^S h, \;\; Q^M(h_f, h_m, d) = \eta_d^M h_f^\alpha h_m^{1-\alpha}$$

Estimation Stratgy

- Some parameters are estimated outside the model or taken directly from the literature
  - AR (1) Labor process for each education level, Correlation of labor shock across spouses, Age profile, Survival rate, etc.

- Other parameters are estimated within the model to minimize the distance between the moments from the model and those calculated from the data.
  - Aggregate variables, such as K/Y, Marital sorting patterns, Frac. single mothers and married households w/ children
  - Marriage and divorce hazard rates
  - Hours worked, employment rates, home time of each type of individuals

Parameters Estimated Endogenously (selected)

Preference	
Discount factor β (1 year)	0.984
Cost of Challenge κ	1.23
Extreme Value shocks	
Marital status specific error s.d. σ_ϵ	2.321
Time allocation choice specific error s.d. σ_ε	0.948
Demographic	
Single e^{nc} Fertility Rate $\pi^{S,nc}$	0.27
Single e^{co} Fertility Rate $\pi^{S,co}$	0.06
Married Fertility Rate π^{M}	0.81
Childcare cost χ	0.082

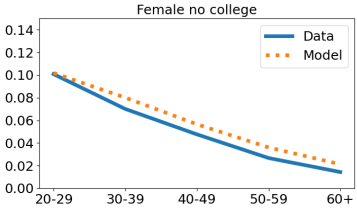
Baseline Results

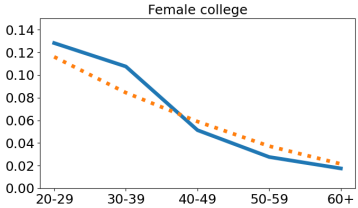
- In order to design the optimal progressive income tax with two-earner households, we want to makes sure that the model captures
  - marital sorting pattern
  - marriage/divorce decisions of individuals
  - labor supply patterns of women, especially married females

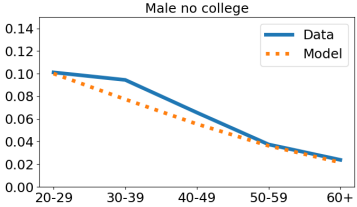
Table 1: Marital Sorting Pattern: ACS (2017) vs Model

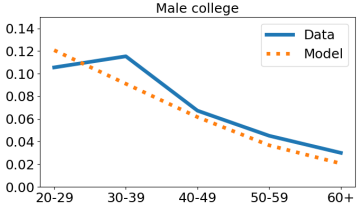
			Female	
		single	e^{nc}	e^{co}
Male	single		0.1779	0.0973
			[0.1568]	[0.0959]
	e^{nc}	0.1762	0.3043	0.1113
		[0.1610]	[0.3174]	[0.1134]
	e^{co}	0.0990	0.0632	0.2460
		[0.0917]	[0.0712]	[0.2453]

1-Year Marriage Hazard Rate

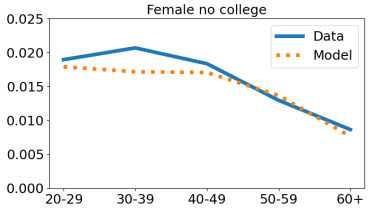


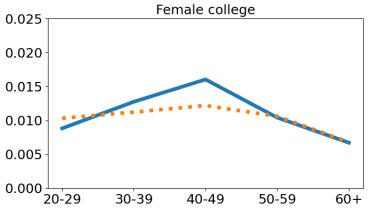


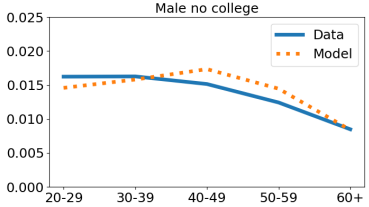


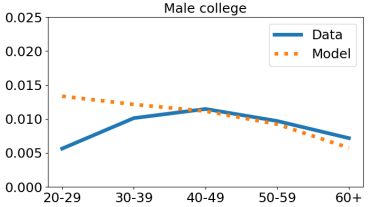


1-Year Divorce Hazard Rate









Aggregate Variables

Description	Target	Model
Capital-to-Output Ratio	2.8	2.79
Frac. with Children Single Female *nc*	0.345	0.352
Frac. with Children Single Female *co*	0.092	0.105
Frac. with Children Married Household	0.779	0.761
M Female Emp Rate w/o children	79.2%	78.1%
M Female Emp Rate w/ children	69.5%	73.7%
M Male Emp Rate	88.7%	90.2%
M Female Hours Worked w/o children	0.353	0.360
M Female Hours Worked w/ children	0.321	0.361
M Male Hours	0.398	0.413

Policy Experiments

Policy Experiments

- We consider two types of policy changes
  - Policy Experiment 1: Apply current US single household tax code to all types of individual (marriage neutral taxation)
  - Policy Experiment 2: Optimal progressive income tax with several specifications, compute parameters to maximize the expected lifetime utility of newborns.
- In both exercises, we focus on the long-run effects of policy reforms.
- Lump-sum transfers/taxes to ensure revenue neutrality.

Policy Experiment 1: Shift to inididual taxation

- To see how endogenous household formation and labor choices are important, we do the following experiments:
  - (CF1): all individuals are subject to the current U.S. tax code for singles (individual taxation) and fully response to the tax change
  - (CF2): individual taxation but assuming no response in marriage decisions of singles, and no response in divorce decisions (including probability of challenge) of married
- (CF2) captures the pure effects of tax change on labor decisions, but without changes coming from the change of intra-household allocations (so it the allocation may not be optimal)

Table 2: (CF1) Sorting (baseline)

			Female	
			e^{nc}	e^{co}
Male	e^{nc}	0.1441	0.1407	0.0870
		[0.1610]	[0.1568]	[0.0959]
			0.3263	0.1214
			[0.3174]	[0.1134]
	e^{co}	0.0836	0.0784	0.2462
		[0.0917]	[0.0712]	[0.2453]

- For example, (e^{nc}, e^{nc}) couples $\uparrow$ by 2.8%

Policy Experiment 1: Shift to inididual taxation

- In (CF1), total number of married household goes up by 3.4%, with all entries go up.
- Before the reform, unequal earning couples benefit from joint filings (marriage bonus)
  - High earning potential look for a spouse (i) low earning potential (ii) less likely to work
- The policy change eliminates such tax benefits
  - Agents less selective to their mate, and marriage happens more (Avg. M hazard rate 3.8% $\uparrow$)
- On the other hand, the degree of sorting shrinks (Frac. same educ. couple 0.752 to 0.741)
- As agents become less picky for their spouse, they are more likely to accept the potential mate in the marriage pool regardless of his/her background
- As they age, less likely to meet a mate in the marriage pool

Policy Experiment 1: Shift to inididual taxation

Description	Baseline	Separate (CF1)	Separate + fixed ms decision (CF2)
Aggregate number of married HH	0.7472	0.7723	–
Measure of same education couples	0.1249	0.1187	0.1249
Capital-to-Output ratio	2.79	-9.3%	-8.6%
Y	0.63	-5.2%	-4.4%
L	0.83	-0.6%	-1.0%
M Female Emp Rate w/o children	78.1%	+4.8%	+3.6%
M Female Emp Rate w/ children	73.7%	+4.7%	+3.6%
M Male Emp Rate	90.2%	-1.2%	-0.7%
M avg. Female Hours Worked w/o children	0.360	+4.0%	+2.1%
M avg. Female Hours Worked w/ children	0.361	+3.8%	+2.8%
M Male Hours	0.413	-4.7%	-3.9%
avg. home production (married)	0.32	-2.1%	-1.4%
Welfare	–	+0.5%	-0.3%
Welfare (female,male)	–	(+1.1%,+0.2%)	(+0.1%,-0.6%)

(CF1) Policy Experiment 1: Shift to inididual taxation

- Separate filing lowers the marginal tax rate on married women
  - works more, but switching from no work to part-time.
- Higher marginal tax rate on married males (primary earner)
  - full worker to part time/no work
- Married household income $\downarrow$ and K and Y $\downarrow$
- Lower capital stock in the economy
  - higher female labor + lower stock results in lower wage rate
  - lower wealth limits the decrease in labor input through income effects

Policy Experiment 1: (CF1) vs (CF2)

- In (CF1), we have 3.4% increase in number of married households and 1 year decrease in avg. marriage age than baseline.
- Increase in avg. female hours worked are 4% (CF1) vs 2.5% (CF2), their employment rate 4.8% vs 3.6%.
  - lower marginal tax rates on the secondary earner encourages to work in the market.
  - the avg. Pareto weight on female conditional on stay married changes from 0.424 to 0.458 in (CF1)
- Improvement of female Pareto weights in (CF1) comes from intra-household allocations through negotiation
  - Probability of Challenge: male 0.73 to 0.64, female 0.44 to 0.47
  - Avg. offer of Pareto weight (numbers are on female): male 0.38 to 0.41, female 0.45 to 0.48

Why female works more with higher Pareto weight

- Women value leisure more than men.
- After the reform,
  - male engages home production more, female less.
  - female works to complement income.
  - female leisure slightly goes up (home production to labor/leisure), while male leisure does not change so much
- Male's marginal return of home production is high but low marginal return from working with higher marginal tax rate
- Change in Pareto weight is reflected mainly in home production and leisure

Optimal Progressive Income Tax

Optimal Progressive Income Tax

- We consider three types of income tax system
  - (Scenario 1): singles vs married (joint)
  - (Scenario 2): individual taxation
- Total tax paid by a household is $\tau(y) = (1 - \tau\widetilde{y}^{-\kappa})y$, where $\widetilde{y}$ is the multiple of mean income ($\widetilde{y} = 2$ means total income of a tax unit is twice of mean income).
- $\widetilde{y}$ changes if tax unit changes.

Table 3: Sorting under Optimal Tax Policy with Household Taxation

			Female	
			e^{nc}	e^{co}
Male			0.1457	0.0915
			[0.1568]	[0.0959]
	e^{nc}	0.1505	0.3243	0.1179
		[0.1610]	[0.3174]	[0.1134]
	e^{co}	0.0876	0.0754	0.2452
		[0.0917]	[0.0712]	[0.2453]

Optimal Income Tax Progressivity (Current US)

Description	Baseline	Full Response	CF2
Avg. Tax Rate (at $\widetilde{y} = 1$)	(10.3%,8.7%)	(11.8%,8.2%)	(12.0%,7.9%)
Mar. Tax Rate (at $\widetilde{y} = 1$)	(13.3%,14.2%)	(14.4%,12.9%)	(15.0%,14.1%)
Aggregate # of married hh	0.7472	0.7508	0.7472
Measure of same education couples	0.1249	0.1203	0.1249
Avg. Married Age	30.77	30.25	30.77
K/Y	2.79	-6.3%	-7.1%
Y	0.63	-4.2%	-4.9%
L	0.83	-1.1%	-1.9%
M Female Emp Rate w/o children	78.1%	-0.6%	-0.2%
M Female Emp Rate w/ children	73.7%	-0.6%	-0.3%
M Male Emp Rate	90.2%	-0.9%	-1.1%
M Female Hours Worked w/o children	0.360	-0.8%	-0.4%
M Female Hours Worked w/ children	0.361	-0.9%	-0.5%
M Male Hours	0.413	-1.1%	-1.8%
Welfare (CEV)	–	+1.4%	+1.1%
Welfare (female,male)	–	(+1.1%,+1.7%)	(+0.4%,+1.8%)

Optimal Income Tax Progressivity (Full response)

- Stronger marriage non-neutrality in optimal policy with Full Response
  - stronger subsidization within married households
- on the other hand, lower marginal tax rates for married households
  - females have tax incentives to work, which increase their Pareto weight and Challenge probability
- In (CF2) case, males challenges too often than Full Response case
  - his Pareto weight tends to be higher than optimal
  - male works less and female works more than Full Response case

Optimal Income Tax Progressivity (Individual Taxation)

Description	Baseline	Full Responses	CF2
Avg. Tax Rate (at $\widetilde{y} = 1$)	(10.3%,8.7%)	(10.1%)	(9.6%)
Mar. Tax Rate (at $\widetilde{y} = 1$)	(13.3%,14.2%)	(14.6%)	(15.3%)
Aggregate # of married hh	0.7472	0.7675	0.7472
Measure of same education couples	0.1249	0.1221	0.1249
Avg. Married Age	30.77	29.69	30.77
K/Y	2.79	-7.7%	-8.6%
Y	0.63	-5.6%	-6.7%
L	0.83	-2.1%	-2.6%
M Female Emp Rate w/o children	78.1%	-0.8%	-0.2%
M Female Emp Rate w/ children	73.7%	-1.2%	-0.3%
M Male Emp Rate	90.2%	-1.3%	-1.8%
M Female Hours Worked w/o children	0.360	-1.1%	-0.2%
M Female Hours Worked w/ children	0.361	-1.3%	-0.5%
M Male Hours	0.413	-1.8%	-2.3%
Welfare (CEV)	–	+1.9%	+1.5%
Welfare (female,male)	–	(+1.7%,+2.1%)	(+0.7%,+2.3%)

Optimal Income Tax Progressivity (CF2)

- Individual taxation lowers marginal tax rates on the secondary earner (given her earning is low)
  - encourages females to work more
  - larger Pareto weight on her, less market works
- Overall, the latter effect is stronger as we can see in Full Response case
- In (CF2), we don't have such an effect
  - married female labor supply does not respond so much

Conclusion

- Construct a model in which both single and married households exist, and taxes affect labor supply patterns and household formations.
- Marital sorting pattern is affected by income taxes through
  - who get married to whom due to the differential tax treatment between singles and married households
  - labor supply patterns of the secondary earner because of marginal tax rates
  - intra-household allocations relative size of income and division of labor
- All model ingredients are essential to analyze the policy changes.

Conclusion

- Welfare maximizing income tax progressivity is
  - higher for singles and lower for married than current tax code if maintain household taxation.
  - lower if shifts to individual taxation.
- We show that endogenous household formation/dissolution and within-household allocation choice is quantitatively important
  - changes in female labor supply (hours worked, employment rates) are underestimated if those are absent
  - cannot capture changes in marital sorting pattern after the policy reform.

Appendix

Empirical Evidence of Effects of Tax reform on Marriage

- Marriage rate and decisions (Alm and Whittington (1995), Alm and Whittington (1999))
  - the percentage of married female 15-44 on difference of tax burdens
  - marriage-tax elasticity is statistically significant, but is less than -0.05 (1% increase by 20% tax fall)
  - however, the elasticity of marriage w.r.t. the marriage penalty is -1.25 at the extreme penalty
- Marriage decisions (Alm and Whittington (1997))
  - delay of marriage decisions on changes in income tax burden upon marriage
  - if the average marriage penalty to a couple doubles, a couple delays marriage by around 1%.

Back

Empirical Evidence of Effects of Tax reform on Marriage

- marital sorting (Chade and Ventura (2002), Siassi (2019))
  - Their theoretical model predicts that the separate filing induce stronger marital sorting (education, income)
  - But taxes do not affect intra-household allocations

Back

End-of-period Problem: Single Working-age Female Household

- Summarize state variables $(a, s^f) = (a, j, e, z, d)$.

- Conditional on the time allocation $t_f \in \mathcal{T}_f$, with no childcare cost

$$V^f(t_f; a, s_f) + \varepsilon_{t_f} = \max_{c, a' \geq 0} u^f(c, \ell_{t_f}, Q) + \varepsilon_{t_f} + \beta \xi^j E \widetilde{V}^f(a', s'_f)$$

$$\text{s.t. } (1 + \tau_c)c + a' = y - \tau^{\mathcal{S}}(y) + a$$

- taxable income $y = \widehat{w}^f(s^f) n^f_{\mathbf{t}} + ra$

- Solution to the Time allocation : $t^*_f(a, s^f) = \arg\max_{t_f} \left\{ V^f(t_f; a, s_f) + \varepsilon_{t_f} \right\}$

Back

End-of-period Problem: Single Working-age Female Household

- Summarize state variables $(a, s^f) = (a, j, e, z, d)$.

- Conditional on the time allocation $t_f \in \mathcal{T}_f$, if pays childcare cost

$$V^f(t_f; a, s_f) + \varepsilon_{t_f} = \max_{c, a' \geq 0} u^f(c, \ell_{t_f}, Q) + \varepsilon_{t_f} + \beta \xi^j E\widetilde{V}^f(a', s'_f)$$

$$\text{s.t. } (1+\tau_c)c + a' = y - \tau^{\mathcal{S}}(y) + a \underbrace{-\widehat{w}^f(s^f)\chi n_t^f}_{\text{childcare cost}}$$

- taxable income $y = \widehat{w}^f(s^f) n_{\mathbf{t}}^f + ra$

- Solution to the Time allocation : $t_f^*(a, s^f) = \arg\max_{t_f} \left\{ V^f(t_f; a, s_f) + \varepsilon_{t_f} \right\}$

Back

End-of-period Problem: Married Working-age Household

- Conditional on $\mathbf{t} \in \mathcal{T}_f \times \mathcal{T}_m$, with no childcare cost

$$\max_{c^f, c^m, a' \geq 0} \lambda \Big[u(c^f, \ell^f_{\mathbf{t}}, Q) + \theta + \varepsilon_{\mathbf{t}} + \beta \xi^j E \widetilde{W}^f(a', \mathbf{s}') \Big] + (1-\lambda) \Big[u(c^m, \ell^m_{\mathbf{t}}, Q) + \theta + \varepsilon_{\mathbf{t}} + \beta \xi^j E \widetilde{W}^m(a', \mathbf{s}') \Big]$$
$$\text{s.t. } (1+\tau_c)(c^f + c^m) + a' = y - \tau^M(y) + a$$

- taxable income $y = \widehat{w}^m(s^m) n^m_{\mathbf{t}} + \widehat{w}^f(s^f) n^f_{\mathbf{t}} + ra$

- $\varepsilon_{\mathbf{t}}$ and match quality θ are common across spouses

Back

End-of-period Problem: Married Working-age Household

- Conditional on $\mathbf{t} \in \mathcal{T}_f \times \mathcal{T}_m$, if pays childcare cost

$$\max_{c^f, c^m, a' \geq 0} \lambda \Big[u(c^f, \ell^f_{\mathbf{t}}, Q) + \theta + \varepsilon_{\mathbf{t}} + \beta \xi^j E \widetilde{W}^f(a', \mathbf{s}') \Big] + (1-\lambda) \Big[u(c^m, \ell^m_{\mathbf{t}}, Q) + \theta + \varepsilon_{\mathbf{t}} + \beta \xi^j E \widetilde{W}^m(a', \mathbf{s}') \Big]$$

$$\text{s.t. } (1+\tau_c)(c^f + c^m) + a' = y - \tau^M(y) + a - \widetilde{w}^f \chi h^f_{\mathbf{t}}$$

- taxable income $y = \widehat{w}^m(s^m) n^m_{\mathbf{t}} + \widehat{w}^f(s^f) n^f_{\mathbf{t}} + ra$

- $\varepsilon_{\mathbf{t}}$ and match quality θ are common across spouses

Back

Value at the Marriage Pool

$$\widetilde{V}^f(a^f, s^f) = \underbrace{(1 - p^j) EV^f(a^f, s^f)}_{\text{no meet}}$$
$$+ p^j \Bigg[\int_{\mathcal{A}\times\mathcal{S}} \Bigg(\underbrace{\mathbb{1}^m(a^f, s^f, a^m, s^m) \max\left\{ EW^f(a^f + a^m, \mathbf{s}, \lambda) + \epsilon_M^f, EV^f(a^f, s^f) + \epsilon_S^f \right\}}_{\text{mate agrees}}$$
$$+ \underbrace{(1 - \mathbb{1}^m(a^f, s^f, a^m, s^m)) \left\{ EV^f(a^f, s^f) + \epsilon_S^f \right\}}_{\text{mate declines}} \Bigg) d\widetilde{\mu}_{Sm}(a^m, s^m) \Bigg]$$

Back

Value at Negotiation Stage

$$\widehat{W}^{S,f}(a,\mathbf{s},\boldsymbol{\lambda},\boldsymbol{\epsilon}) = \underbrace{\mathbb{1}^{S,m}(a,\mathbf{s},\boldsymbol{\lambda},\boldsymbol{\epsilon}^m)\Big(EW^f(a,\mathbf{s},1/2)+\epsilon_M^f\Big)}_{\text{husband } \textit{Satisfied}}$$
$$+\underbrace{\Big\{1-\mathbb{1}^{S,m}(a,\mathbf{s},\boldsymbol{\lambda},\boldsymbol{\epsilon}^m)\Big\}\Big[\max\Big\{EW^f(a,\mathbf{s},\lambda^m)+\epsilon_M^f, EV^f(a/2,s^f)+\epsilon_S^f\Big\}-\kappa\Big]}_{\text{husband Challenge}}$$

$$\widehat{W}^{C,f}(a,\mathbf{s},\boldsymbol{\lambda},\boldsymbol{\epsilon}) = \underbrace{\mathbb{1}^{S,m}(a,\mathbf{s},\boldsymbol{\lambda},\boldsymbol{\epsilon}^m)\mathbb{1}^{A,m}(a,\mathbf{s},\lambda^f,\boldsymbol{\epsilon}^m)\Big(EW^f(a,\mathbf{s},\lambda^f)+\epsilon_M^f\Big)}_{\text{husband } \textit{Satisfied} \text{ and Accept}}$$
$$+\underbrace{\Big\{1-\mathbb{1}^{S,m}(a,\mathbf{s},\boldsymbol{\lambda},\boldsymbol{\epsilon}^m)\mathbb{1}^{A,m}(a,\mathbf{s},\lambda^f,\boldsymbol{\epsilon}^m)\Big\}\Big(EV^f(a/2,s^f)+\epsilon_S^f\Big)}_{\text{otherwise}}-\kappa$$

Back

Start-of-Period Problem: Married Working-age Household

		Husband	
		Satisfied	Challenge
Wife	Satisfied	$\lambda = 1/2$	λ^m or Div.
	Challenge	λ^f or Div.	Divorce

- First, they choose *Satisfied* or *Challenge*

Back

Start-of-Period Problem: Married Working-age Household

		Husband	
		Satisfied	Challenge
Wife	Satisfied	$\lambda = 1/2$	λ^m or Div.
	Challenge	λ^f or Div.	Divorce

- First, they choose *Satisfied* or *Challenge*
  - if both Accept, set PW $\lambda = 1/2$

Back

Start-of-Period Problem: Married Working-age Household

		Husband	
		Satisfied	Challenge
Wife	Satisfied	$\lambda = 1/2$	λ^m or Div.
	Challenge	λ^f or Div.	Divorce

- First, they choose *Satisfied* or *Challenge*
  - If both Challenge, they divorce

Back

Start-of-Period Problem: Married Working-age Household

		Husband: Satisfied	Husband: Challenge
Wife	Satisfied	$\lambda = 1/2$	λ^m or Div.
	Challenge	λ^f or Div.	Divorce

- First, they choose *Satisfied* or *Challenge*
  - Now suppose wife chooses *Challenge* but husband selects *Satisfied*,
- Second, wife offers λ and husband choose Accept or Reject.
  - husband receives new PW (λ^f) offer from wife, and decides accept or reject the offer
  - λ^f is chosen so that it maximizes the expected value of the wife

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