Life-Cycle Fertility, Human Capital, and Family Policies: A Discrete-Continuous Choice Framework

George-Levi Gayle[1] Andrés Hincapié[2] Robert A. Miller[3]

[1]Department of Economics, Washington University in St. Louis, Federal Reserve Bank of St. Louis, and NBER
[2]Department of Economics, University of North Carolina at Chapel Hill
[3]Tepper School of Business, Carnegie Mellon University.

November 20, 2025

Motivation

Female labor supply and fertility behavior entail complex dynamics

- Childrearing demands, disproportionately borne by women, impact labor supply
- Labor supply provides monetary resources but it can make having children difficult
- These choices can have substantial socio-economic consequences

Numerous policies have targeted fertility and women's labor supply

- Committee on Women's Rights (1990), Olivetti and Petrongolo (2017), Albanesi, Olivetti, and Petrongolo, (2022)

Policy evaluation entails several challenges

- Dynamic interdependence between female labor supply and fertility behavior
- The complexity of the policy arrangements (ex: interaction between tax schedules and leave policies)

This Paper

We address the challenges combining **policy variation** + **a structural discrete-continuous choice model**

- Extensive quasi-experimental variation over time and across US states in leave and tax-transfer policies
- Dynamic choices of work, labor hours, and fertility
- Counterfactually implement local, in-sample policies at the national level

Simulated National Implementation

- **Objective:** to assess the impact of the national implementation of locally observed leave and tax-transfer policies on:
  - leave take-up, fertility, labor market outcomes, motherhood penalty, tax revenue, and policy costs

- **Methodology**
  - Uses structural parameters, CCPs and the representation of the continuation value ($A(x_t)$ index) to forward simulate choices and outcomes under each of the policies until age 64
  - Leverages policy variation already embedded in the dynamic model
  - Backward-solution is not necessary

- **Initial condition**
  - Balanced sample of 1,970 unique observed women around entry into the workforce
  - Each one replicated 30 times, creating a simulation sample of 59,100 women

- **Policy grid**
  - There are 735 possible policy combinations (given the leave and tax-transfer policies observed)
  - We observe 129 of these combinations in the data
  - For simulation we focus on a grid of 28 combinations: 7 leave policies $\times$ 4 tax-transfer policies

Preview of Main Results

- **Labor**
  - All leave policies increase labor market outcomes, such as participation and income over the life cycle, despite a higher motherhood penalty
  - FMLA (one-tier) and leave policies with *two-tier eligibility* are particularly effective at increasing labor market attachment and income
- **Fertility**
  - Leave policies generally reduce completed fertility, particularly two-tier policies that combine protected and paid leave
  - Tax-transfer regimes with high child transfers lead to higher completed fertility, they can offset some of the negative effects of leave policies on fertility
- **Tax revenue and policy costs**
  - All leave policies increase tax revenue over the life cycle net of policy costs; two-tier policies yield the highest gains

Mechanisms

- **Work-leisure tradeoff**
  - Wage-returns to human capital: depreciation and a part-time wage penalty, especially for women with limited labor attachment
  - Participation costs increase with birth, decrease with age and education
  - Marginal utility of leisure displays adjacent complementarity, supporting persistent labor attachment
- **Fertility and child costs**
  - Children aged 1-3 impose the highest nurturing time costs
  - Strong preference for birth spacing of 2-4 years (first two children)
- **Policies**
  - Two-tier leave policies provide benefits for women at two different levels of labor market attachment
  - Tax-transfer policies with high child transfers reduce the need for labor income, which lowers labor supply
  - Costs are temporary but benefits are long-term

Literature Summary

- **Public opinion and cross-country comparisons**
  - Goldstein, Lutz, and Testa, 2003; Billari and Kohler, 2004; Kögel, 2004
- **Time series and event studies**
  - Butz and Ward, 1979, 1980; Büttner and Lutz, 1990; Milligan, 2005; Laroque and Salanié, 2008; Cohen et al., 2013
- **Causal studies on leave policies**
  - Baum, 2003; Bartel et al., 2014; Flores, Gayle, and Hincapié, 2024; Lalive and Zweimüller, 2009
- **Dynamic joint determination of labor and fertility**
  - Hotz and Miller, 1988; Francesconi, 2002; Keane and Wolpin, 2010; Adda et al., 2017; Khorunzhina and Miller, 2022; Wang, 2022

Main Contributions

- **Policy evaluation:** evaluate a wide array of leave and tax-transfer policies taking into account dynamic selection in labor supply and fertility
- **Long-term outcomes:** evaluation of long-term outcomes (ex: completed fertility)
- **Eligibility structure:** analyze the impact of the tier structure of leave policies
- **Continuous hours decision:** capture observed variation; crucial for the effects of leave policies and marginal tax rates
- **Nurturing time:** integrate the time cost of children in the dynamic labor-fertility trade-off
- **Employer responses:** capture wage responses to the policy environment
- **Identification:** formally prove identification of the utility function

- Policy Environment
- Individual Data
- Model
- Identification
- Estimation
- Estimates
- National Implementation of Policies
- Conclusion

Leave Policies in the United States, 1968-2017

Policy data

- State and federal leave policies in the US from 1968 to 2017
- Sources include: Skolnik (1952), Women's Legal Defense Fund (1991), Women's Bureau (1993), Kallman Kane (1998), Waldfogel (1999), and government websites

Policy characteristics

- **Tiers**: how many levels of eligibility (one or two)
- **Eligibility**: work hours in the prior year required to access benefits
- **Generosity**:
  - *Protection*: weeks of job-protected leave grated at each tier
  - *Pay*: weeks of paid leave grated at each tier
  - *Replacement rate*: percentage of wages paid during paid leave
- In total, each leave policy is described by 9 variables

Leave Policies in the United States, 1968-2017

	One-tier Policies				*Two-tier Policies*							
					Tier 1				*Tier 2*			
	Eligibility	*Generosity*			*Eligibility*	*Generosity*			*Eligibility*	*Generosity*		
		Protected	*Paid*	*Rate*		*Protected*	*Paid*	*Rate*		*Protected*	*Paid*	*Rate*
	(hours)	*(weeks)*	*(weeks)*		*(hours)*	*(weeks)*	*(weeks)*		*(hours)*	*(weeks)*	*(weeks)*	
	0	0	6	0.55	0	6	0		360	18	0	
	0	6	0		0	6	0		1000	18	0	
	0	6	6	0.55	0	6	0		1000	22	0	
	0	8	0		0	6	0		1250	12	0	
	1	8	0		0	6	6	0.55	1250	18	6	0.55
	1	10	0		0	6	12	0.55	1250	18	12	0.55 CA 04-17
	160	0	10	0.50	0	6	0		1250	18	0	
	360	12	0		0	8	0		1250	20	0	
RI 79-86	400	10	10	0.55	0	6	0		1820	12	0	WA 90-92
	520	8	0		1	10	0		1250	12	0	
	560	0	6	0.58	160	0	10	0.50	1250	12	10	0.50
	560	6	6	0.58	400	10	10	0.55	1250	22	10	0.55
	643	24	0		400	14	10	0.55	1250	26	10	0.55
NJ 79-89	800	0	10	0.67	400	10	10	0.55	1560	23	10	0.55
	1000	8	0		520	8	0		1250	12	0	
	1000	32	0		560	6	6	0.58	1250	18	6	0.58
	1040	6	0		800	0	10	0.67	1000	16	10	0.67 NJ 90-08
FL >93	1250	12	0		800	0	10	0.67	1000	16	16	0.67
	1250	14	0		1040	6	0		1250	12	0	
	1560	12	0									
	2080	12	0									
Mean	628	9.2	2.6	0.57	267	6.3	4.4	0.57	1197	17.1	4.7	0.57
SD	(590)	(7.7)	(3.9)	(0.05)	(341)	(3.5)	(5)	(0.06)	(280)	(4.3)	(5.5)	(0.06)

Model

Tax-Transfer Policies

- Tax-transfer schedule $T(y)$ (y = gross income) backed out using the flexible function (Feldstein, 1969; Heathcote, Storesletten, and Violante, 2011):

$$T(y) = \left(\underbrace{\pi_0^{tax}}_{\text{lump sum}} + \underbrace{\pi_1^{tax}}_{\text{slope}} y \; \overbrace{\pi_2^{tax}}^{\text{progressivity}} \right)$$

- **Details**
  - π^{tax} depend on marital status (all) and number of dependent children (lump sum and slope)
  - Data from the Panel Study of Income Dynamics (PSID)
  - NBER's TAXSIM program (Feenberg and Coutts, 1993)

- **Policy variation**
  - Captures six major reforms at the federal level
    - Economic Recovery Tax Act of 1981 (ERTA), Tax Reform Act of 1986 (TRA), Omnibus Budget Reconciliation Act of 1990 (OBRA-90), Personal Responsibility and Work Opportunity Reconciliation Act of 1996 (PRWORA), Economic Growth and Tax Relief Reconciliation Act of 2001, the Tax Relief Act of 2010
  - Overall 21 tax-transfer regimes (described by 10 variables each)

Tax-Transfer Regimes in the US, 1968-2017

	Married						*Not Married*					
	Lump sum($)		*Slope (%)*		*Prog.*	*Marg. (%)*	*Lump sum($)*		*Slope (%)*		*Prog.*	*Marg. (%)*
	Base	n_t	*Base*	n_t			*Base*	n_t	*Base*	n_t		
	-9,966	-2,397	15.5	0.455	1.05	31.7	-2,924	-878	9.7	0.392	1.08	28.3
	-3,859	-1,789	0.4	0.005	1.32	22.7	-3,274	-439	7.2	-0.107	1.10	22.5
CA 68-81	-8,563	-1,575	5.5	0.355	1.16	44.2	-3,018	-2,005	0.9	-0.023	1.32	35.5
	-8,244	-1,336	4.4	-0.047	1.15	27.8	-1,775	-826	1.5	0.026	1.23	24.6
	-11,668	-1,330	15.8	-0.018	1.06	33.0	-2,771	-731	8.2	0.216	1.10	28.8
	-2,872	-1,325	0.9	0.011	1.26	24.8	-897	-559	1.7	0.064	1.21	20.8
	-12,138	-1,253	11.4	-0.148	1.08	31.8	-3,450	-251	6.4	-0.323	1.13	25.8
	-4,272	-1,208	3.1	0.028	1.18	29.4	-1,843	-400	10.0	-0.299	1.08	24.3
	-6,002	-1,015	2.8	-0.081	1.17	22.7	-5,326	92	21.4	-1.152	1.03	26.5
	-4,437	-905	2.1	-0.035	1.21	28.4	-1,187	-560	1.8	-0.033	1.23	24.0
	-5,330	-706	4.0	0.060	1.16	29.3	-2,002	586	5.0	-1.267	1.14	13.5
	-4,051	-562	0.3	0.004	1.39	38.5	-1,678	-2,217	0.2	0.013	1.42	36.3
	-5,836	-546	1.5	0.063	1.25	38.5	-678	-381	0.2	-0.001	1.45	30.1
	-3,756	-329	0.5	0.017	1.31	26.0	-688	-201	0.2	-0.004	1.40	21.5
	-2,626	-289	0.8	0.002	1.27	23.2	-516	-223	0.2	-0.004	1.40	20.0
	-7,318	-284	4.9	0.105	1.14	31.1	-1,080	-535	1.1	0.007	1.27	26.1
	-5,691	-277	0.8	0.014	1.31	41.2	-1,125	-191	0.3	-0.005	1.41	31.8
GA 91-96	-4,158	-275	1.6	-0.020	1.23	29.4	-1,443	-527	2.4	-0.009	1.21	26.7
	-7,324	-251	3.1	0.018	1.19	33.4	-1,421	-459	1.2	-0.003	1.27	28.4
	-2,817	-143	0.1	0.000	1.46	32.8	-929	-1,224	0.1	0.000	1.51	29.0
	-5,001	238	0.4	0.003	1.35	33.5	-713	-75	0.2	-0.003	1.44	25.6
Mean	-5,997	-836	3.8	0.038	1.22	31.1	-1,845	-572	3.8	-0.120	1.26	26.2
SD	2,791	656	4.7	0.133	0.11	5.9	1,216	633	5.3	0.390	0.15	5.2

Notes: *Prog.*= progressivity; *Marg.*= marginal tax rate for a woman with two kids and a household income of $50K

Variation in Average and Marginal Tax Rates

$$T(y) = \left(\pi_0^{tax} + \pi_1^{tax} y^{\pi_2^{tax}}\right)$$

	Married		*Not Married*	
	Mean	SD	Mean	SD
Average tax rate (%)				
No children	9.12	2.72	18.09	2.34
2 children	6.23	4.61	14.97	2.45
Marginal tax rate (%)				
No children	25.48	4.66	27.15	4.20
2 children	26.03	5.32	26.20	5.16

Notes: unit of observation is a tax-transfer policy

Individual Data and Key Variables

- **Data source**
  - 50 years of individual data from the (PSID), 1968–2017
- **PSID files used**
  - Family-Individual File
  - Childbirth and Adoption History File
  - Marriage History File
- **Key variables**
  - Labor: annual hours worked, real hourly earnings
  - Demographic: birth history, household non-labor income, age, education, race, partnership status
  - Partner traits: age, education, labor participation, and income
- All monetary values expressed in real dollars indexed to 2015

Measuring Leave Take-up

How we construct the measure

- PSID does not have an explicit measure of leave take-up
- We construct a measure of leave take up for women with a birth in t or $t-1$ by:
  - Compute gap between current work hours and most recent work hours without birth
  - Compare the gap against policy availability and eligibility

Features of the measure

- Does not assume all leave is used
- Conditional on reducing hours, women use benefits*
- Gap in hours is not due to a change in jobs/contracts

Protected vs. paid leave

- Protected leave: *taken if she returns to work within available protected time
- Paid leave: taken regardless of length of hours reduction, since benefits are immediate

A Model of Fertility and Female Labor Supply with Leave and Tax-Welfare Policies

- **Notation**
  - $t \in \{0, 1, \ldots, T\}$: woman's age in years beyond adolescence
  - z_t: her characteristics (age, race, education, partnership status)
  - π_t: policy environment
- **Choices**
  - $c_t \in \mathbf{R}_+$: consumption
  - $h_t \in [0, 1]$: working hours; $\quad d_t = 1\{h_t > 0\}$
  - b_t: whether to have a child at age t ($t \leq T^F$, fertile age)
  - $\bar{d}_{kt} \in \{0, 1\}$: discrete choice indicator, $k \in \{1, \ldots, 4\}$ (combinations of d_t and b_t)
- **Human capital**
  - $\underline{h}_{t-1} = [h_{t-1}, \ldots, h_{t-\rho_w}]$
  - ρ_w: retention window, full depreciation after

Time Cost of Child Nurturing and Time Constraint

$$\varsigma_t = \sum_{s=0}^{\rho_c} \phi_s b_{t-s} + \phi \sum_{s=\rho_c+1}^{17} b_{t-s}$$

- ς_t: nurturing time required given children's ages
- ϕ_s: time cost of a child of age s
- ρ_c: old (underage) children have the same time cost
- Nurturing time bounds time available for work (h_t) and leisure (l_t)

$$l_t = 1 - h_t - \varsigma_t$$

- Leisure is the residual time after work and nurturing
- Trade-offs: leisure vs labor and nurturing responsibilities

Partnership Dynamics

- Not a choice
- A joint distribution $G(\cdot)$ of partnership status m_t and partner traits z'_t
- Distribution depends of previous choices and policy environment

$$G(m_t, z'_t | m_{t-1}, z_{t-1}, z'_{t-1}, x_{t-1})$$

  - m_t: partnership status (married, cohabiting, single)
  - z'_t: partner's education
  - x_t: state variables of the problem

Types of Leave: Protected (h_1^ℓ) and Paid (h_2^ℓ)

$$h_t^\ell = \{h_{1t}^\ell, h_{2t}^\ell\}$$

- **Protected leave** (h_{1t}^ℓ):
  - operationalized as protection against human capital losses (decreases in wages)
  - generates protected human capital (h_t^*):

$$h_t^* = h_t + h_{1t}^\ell$$

  - targets longer term income (until protected human capital depreciates)

- **Paid leave** (h_{2t}^ℓ):
  - income replacement
  - $\iota(\pi_t) \in [0, 1]$: replacement rate
  - targets current income

Leave Granted, $\bar{h}_t$

$$\bar{h}_t = \begin{pmatrix} \bar{h}_{1t} \\ \bar{h}_{2t} \end{pmatrix} = b_t \cdot \underbrace{\begin{pmatrix} \kappa_1(\pi_t, h_{t-1}) \\ \kappa_2(\pi_t, h_{t-1}) \end{pmatrix}}_{\substack{\text{policy benefits \&} \\ \text{eligibility requirements}}} \cdot \underbrace{\begin{pmatrix} h_t^B(\underline{h}_{t-1}) \\ \hline 52 \end{pmatrix}}_{\substack{\text{most recent work} \\ \text{hours per week}}} \in [0,1)^2$$

- $\kappa_1, \kappa_2 \in [0, 1)$ (protected κ_1, paid κ_2):
  - follows directly from table of policies Policies
  - depends on policy environment and prior work
  - captures generosity (weeks granted) and eligibility (prior work required)
- h_t^B (base hours):
  - h_t^B = most recent work hours while not having a birth
  - used to transform *weeks of leave* (from κ) into *hours of leave*
  - captures the nature of the labor contract (ex: full-time vs part-time)

Example of Leave Granted

Consider the following one-tier policy:

- *eligibility*: women must have worked at least 0.11 hours last year ($\approx 1,040/(365 \times 24)$, i.e. part-time)
- *generosity*: 16 weeks of protected leave upon birth, no paid leave

Now consider a woman who:

- has a birth at t, $b_t = 1$
- worked with full-time intensity last year, $h_{t-1} = 0.24$
- did not have a birth in $t-1$, $h_t^B(\underline{h}_{t-1}) = 0.24$
- $\rightarrow \kappa_1(\pi_t, h_{t-1}) = \mathbf{1}\{0.24 \geq 0.11\} \times 16 = 16$ wk
- Then, leave granted is:

$$\bar{h}_t = b_t \cdot \begin{pmatrix} \kappa_1(\pi_t, h_{t-1}) \\ \kappa_2(\pi_t, h_{t-1}) \end{pmatrix} \cdot \left(\frac{h_t^B(\underline{h}_{t-1})}{52} \right) = 1 \cdot \begin{pmatrix} 16 \\ 0 \end{pmatrix} \cdot \left(\frac{0.24}{52} \right)$$

Protected Leave Take-Up, h_{1t}^{ℓ}

$$h_{1t}^{\ell} = (h_t^B - h_t)\mathbf{1}\{0 \leq h_t^B - h_t \leq \bar{h}_{1t}\}$$

- If:
  - $h_t^B - h_t \geq 0$: there was a reduction in hours relative to base
  - $h_t^B - h_t \leq \bar{h}_{1t}$: reduction is at most as large as granted protected leave
- Then:
  - $h_t^B - h_t \geq 0$: protected take-up is equal to reduction in hours
  - Otherwise take-up is zero
- Features
  - Captures potential loss in protection if reduction is too large
  - Indirectly determined by the choice of hours (not an additional choice)
  - Allows for null, partial, or full use of protected leave

Paid Leave Take-Up, h_{2t}^{ℓ}

$$h_{2t}^{\ell} = (h_t^B - h_t)\mathbf{1}\{0 \leq h_t^B - h_t \leq \bar{h}_{2t}\} + \bar{h}_{2t}\mathbf{1}\{h_t^B - h_t > \bar{h}_{2t}\}$$

- $(h_t^B - h_t)\mathbf{1}\{0 \leq h_t^B - h_t \leq \bar{h}_{2t}\}$:
  - same rule as for protected leave if reduction in hours does not surpass paid leave granted
- $\bar{h}_{2t}\mathbf{1}\{h_t^B - h_t > \bar{h}_{2t}\}$:
  - if reduction surpasses paid leave granted then take-up equals amount granted $\bar{h}_{2t}$
- Features
  - Paid leave is not lost even if reduction is larger than leave granted (unlike protected leave)
  - Indirectly determined by the choice of hours (not an additional choice)
  - Allows for null, partial or full use of paid leave

Household Income: Women's Wages

$$w_t = \omega_t \mu \exp\left\{ \sum_{r=1}^{\rho_r} \mathbf{1}\{\pi_t = \pi_r\} \left[z_t' B_{r,3} + \sum_{s=1}^{\rho_w} \left(\delta_{r,1s} h^*_{t-s} + \delta_{r,2s} d_{t-s} \right) \right] \right\}$$

- Depends on demographics (z_t) and protected human capital
- ω_t: aggregate shock (calendar year effect) to labor efficiency for a women of age t
- μ: fixed individual-specific productivity
- Returns to human capital depend on policy regime

Household Income: Gross and Net Income

Gross Income

$$W_k(h,x) = \underbrace{w(x)h}_{\text{own labor}} + \underbrace{w(x)\iota(\pi)h_2^{\ell}}_{\text{replacement}} + \underbrace{e'(x)}_{\text{partner labor}} + \underbrace{e^{NL}(x)}_{\text{non-labor}}$$

Net Income

$$\Upsilon_k(h,x) = W_k(h,x) - \underbrace{\left(\pi_{k0}^{tax}(x) + \pi_{k1}^{tax}(x) W_k(h,x)^{\pi_{k2}^{tax}(x)}\right)}_{\text{tax-transfer burden, } T(W)}$$

State Variables

$$x_t \equiv \left(z_t, z_t', d_t', h_{t-\rho_w}, \ldots, h_{t-1}, h^{\ell}_{1t-\rho_w}, \ldots, h^{\ell}_{1t-1}, \underline{a}_t, e_t^{NL}, \pi_t, \underline{\omega}_t\right)'$$

- x_t is the state vector containing individual and household characteristics:
  - z_t, z_t': demographics (e.g., age, education, race, partnership status)
  - d_t': partner's labor force participation
  - $h_{t-\rho_w}, \ldots, h_{t-1}$: recent labor supply hours
  - $h^{\ell}_{1t-\rho_w}, \ldots, h^{\ell}_{1t-1}$: recent protected leave take-up
  - $\underline{a}_t$: ages of children
  - e_t^{NL}: realized non-labor income at t
  - π_t, ω_t: policy environment and other aggregate factors

Lifetime Utility Function

$$-E\Bigg\{\sum_{t=0}^{T^R}\sum_{k\in C_t}\beta^t\bar{d}_{kt}\exp\Big(-\alpha c_t-u_{kt}^{(\ell)}(h_t,x_t)-u_{kt}^{(b)}(x_t)-h_{kt}\xi_t-\varepsilon_{kt}\Big)$$
$$+\sum_{t=T^R+1}^{T}\beta^t\exp(-\alpha c_t)\Bigg\}$$

- CARA with absolute risk aversion α
- $u_{kt}^{(\ell)}(h_t,x_t)$: utility from leisure given choice k
- $u_{kt}^{(b)}(x_t)$: utility from birth given choice k
- ξ_t: idiosyncratic marginal disutility from work (not observed before discrete choice)
- ε_{kt}: idiosyncratic preference disturbance for each discrete choice
- T^R: retirement age, after which only consumption affects utility
- C_t: discrete choice set shrinks after fertility age, $t > T^F$
- Individuals are surprised by leave and tax-transfer policy innovations

Utility Function

- Utility from leisure and work ($\widetilde{x}_t \subset x_t$: age, education, race, partnership status)

$$u_{kt}^{(\ell)}(h_t, x_t) \equiv \underbrace{\widetilde{x}_t' B_0 d_{kt}}_{\text{participation cost}} + \underbrace{\widetilde{x}_t' B_1 l_{kt} + \delta_0 l_{kt}^2}_{\text{leisure utility}} + \underbrace{\sum_{s=1}^{3} \delta_s l_{kt} l_{t-s}}_{\substack{\text{intertemporal} \\ \text{leisure interactions}}}$$

- Utility from birth

$$u_{kt}^{(b)}(x_t) \equiv b_{kt} \left(\underbrace{\widetilde{x}_t' \tilde{\gamma}_0 d_{kt}}_{\text{birth utility working}} + \underbrace{\widetilde{x}_t' \gamma_0 (1 - d_{kt})}_{\text{birth utility not working}} + \underbrace{\sum_{s=1}^{4} \gamma_s b_{t-s} + \gamma_b \sum_{s=5}^{17} b_{t-s}}_{\text{birth spacing utility}} \right)$$

Budget Constraint: Law of Motion for Savings

$$s_{t+1} = (1 + r_{t+1})(s_t + \Upsilon_k(h_t, x_t) - c_t)$$

- s_t: savings
- r_{t+1}: interest rate
- Total resources at t (savings s_t and net income Υ_k) must cover current consumption c_t and expected present value of next period's savings s_{t+1}.
- Solution to the savings problem is analytical (Margiotta and Miller, 2000)
- Regression analysis suggests idiosyncratic income shocks do not affect birth decisions as opposed to permanent income Birth and income shocks

Optimal Choices: Index of Human Capital

$$A_t(x_t) \equiv \sum_{k \in C_t} p_{kt}(x_t) \exp\left(\frac{-\overline{u}_k(x_t)}{B_t}\right) E\left[\exp\left(\frac{-\varepsilon_{kt}^*}{B_t}\right) \middle| x_t\right]$$
$$\times \left[\int\left(\int A_{t+1}(x_{t+1}) g_{kh}(x_{t+1}|x_t) dx_{t+1}\right) q_k(h|x_t) dh\right]^{1-\frac{1}{B_t}}$$

- $A_t(x_t)$: index of household capital at time t, continuation value
- $p_{kt}(x_t)$: conditional choice probability of alternative k
- $\overline{u}_k(x_t)$: expected per-period utility
- B_t: bond price induced by interest rate r_t
- $g_{kh}(x_{t+1}|x_t)$: density of future states based on current choices
- $q_k(h|x_t)$: density of hours (induced by idiosyncratic marginal disutility from work ξ_t)
- $A_{T^R+1}(x_{T^R+1}) \equiv 1$ (no value of human capital upon retirement)
- ε_{kt}^*: truncated variable that takes on the value of ε_{kt} only when $\bar{d}_{kt} = 1$.

Optimal Discrete Choices: Participation, Birth

$$\sum_{k \in C_t} \bar{d}_{kt} \left[\overline{u}_k(x_t) - (B_t - 1) \ln \left[\int \left(\int A_{t+1}(x_{t+1}) g_{kh}(x_{t+1}|x_t) dx_{t+1} \right) q_k(h|x_t) dh \right] + \varepsilon_{kt} \right]$$

- At each age before retirement ($t \leq T^R$)
- Woman maximizes a weighted sum of current utility and future value
  - Expected current utility: net income, non-pecuniary benefits from current work and birth choices, and idiosyncratic preference shocks
  - Expected future value: affected by the accumulation of human capital and changes to family composition
- Given function A_t it is a standard discrete choice problem
- Derivation follows prior work (Altuğ and Miller, 1998; Gayle, Golan, and Miller, 2015; Hincapié, 2020; Khorunzhina and Miller, 2022)

Optimal Hours

$$-\xi_t = \alpha w(x_t)\left(1+\iota(\pi)\frac{\partial h^{\ell}_{2t}}{\partial h}\right)\left[1-\pi^{tax}_{kt1}(x_t)\pi^{tax}_{kt2}(x_t)W_k(h_{kt},x_t)^{\pi^{tax}_{kt2}(x_t)-1}\right]+\frac{\partial u_k\left(h_{kt},x_t\right)}{\partial h}$$
$$-\frac{(B_t-1)}{\int A_{t+1}(x_{t+1})g_{kh}(x_{t+1}|x_t)dx_{t+1}}\times\int\left[\frac{\partial A_{t+1}(x_{t+1})}{\partial h}+\frac{A_{t+1}(x_{t+1})}{g_{kh}(x_{t+1}|x_t)}\frac{\partial g_{kh}(x_{t+1}|x_t)}{\partial h}\right]g_{kh}(x_{t+1}|x_t)dx_{t+1}$$

for $k=2,4$ (work and no birth, work and birth)

- First order condition balances utility and income effects to determine optimal hours:
  - marginal disutility of work (ξ_t), known when deciding hours
  - marginal effect on current net income (labor, replacement, tax-transfer burden)
  - marginal non-pecuniary benefits from current leisure (including interactions with past leisure)
  - marginal effect on household continuation value (future wages via changes in protected human capital, future leave availability via satisfaction of eligibility requirements, future utility of leisure)

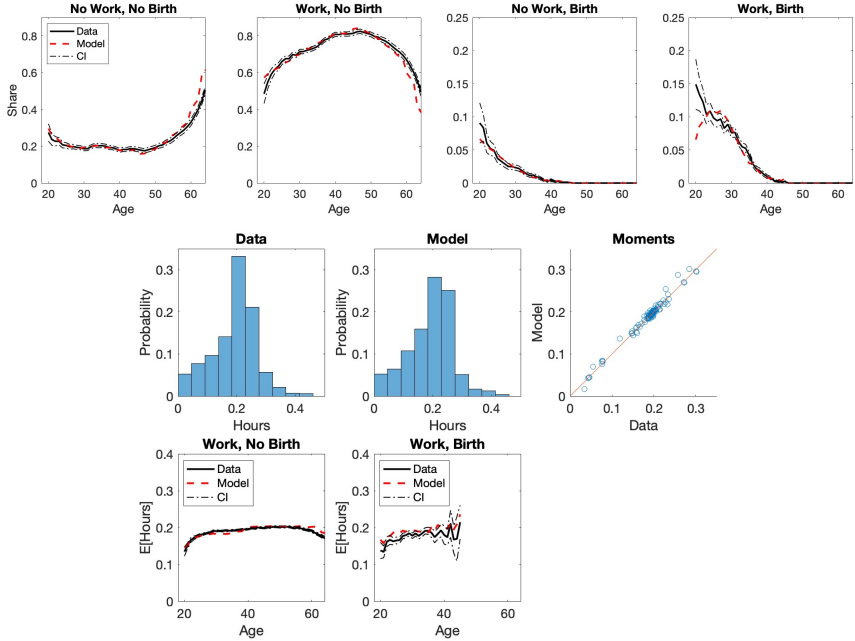
Identification: Overview

- **Proposition 1:** representation of the household capital value index and the ex-ante conditional value function in terms of a path of choices (Arcidiacono and Miller, 2019)
  - Path used: no work and no birth ($k = 1$) from $t + 1$ on
- **Corollary 1.1:** semi-parametric identification of expected per-period utility $\overline{u}_k(x_t)$
  - Standard result in the discrete choice literature, except here we have to account for the preference shock ξ from the continuous choice
  - Hence, only the expected utility is identified (up to standard normalization)
- **Proposition 2:** marginal utility $\frac{\partial u_k^{(\ell)}(h^*, \widetilde{x}_t)}{\partial h}$ and absolute risk-aversion α are identified
  - For any observed value of optimal hours h^* and $\widetilde{x}_t \subset x_t$
  - Requires exclusion restriction and at least one demand-side instrument $\widetilde{\nu}_t$ (e.g. policy variation)
- **Corollary 2.1:** utility function $u_k^{(\ell)}(\widetilde{h}, \widetilde{x}_t)$ is identified
  - Yields from Corollary 1.1 and Proposition 2

Estimation: Overview

- Follows identification strategy and proceeds in three stages leveraging quasi-experimental variation in policy across states and over time
  - **Stage I**: wage and income equations, partnership dynamics, conditional choice probabilities
  - **Stage II**: marginal utility of leisure, absolute risk aversion; uses the Euler equation for optimal hours; method: SMM
  - **Stage III**: remaining parameters from labor and birth discrete choices; uses the log odds ratio in terms of ex-ante conditional value functions; method: quasi-MLE

Model Fit



Notes: hours scaled as a fraction of annual hours (hours/(24×365)). The moments displays the estimation moments in the second stage, all in terms of scaled hours.

Estimates

Work-Leisure Tradeoffs

- *Wage-returns to human capital*
  - High depreciation: returns to lag human capital decline rapidly
  - Part-time penalty: human capital accumulated while working part-time can decrease wages
- *Partnership dynamics*
  - Labor market attachment: $\downarrow$ likelihood of staying single, $\uparrow$ likelihood of separating
- *Utility*
  - Participation cost: $\downarrow$ with age and education, $\uparrow$ for black and partnered women
  - Marginal utility of leisure: $\uparrow$ with education, displays adjacent complementarity

Fertility Tradeoffs

- *Time cost of children*
  - Mothers with two children 1 to 3 yrs old pay a time cost $\sim$ 28% full-time hours
- *Partnership dynamics*
  - Recent births: $\uparrow$ likelihood of staying single, $\downarrow$ likelihood of separating
- *Lifetime expected utility from birth*
  - $\uparrow$ for black, partnered and educated women, $\downarrow$ for working mothers
  - Spacing: $\uparrow$ utility from births between two and four years apart

National Implementation: Setup

- **Objective:** to assess the impact of the national implementation of locally observed leave and tax-transfer policies on:
  - leave take-up, fertility, labor market outcomes, motherhood penalty, tax revenue, and policy costs

- **Methodology**
  - Uses structural parameters, CCPs and the representation of the continuation value ($A(x_t)$ index) to forward simulate choices and outcomes under each of the policies until age 64
  - Leverages policy variation already embedded in the dynamic model
  - Backward-solution is not necessary

- **Initial condition**
  - Balanced sample of 1,970 unique women around entry into the workforce
  - Each one replicated 30 times, creating a simulation sample of 59,100 women

- **Policy grid**
  - There are 735 possible policy combinations (given the leave and tax-transfer policies observed)
  - We observe 129 of these combinations in the data
  - For simulation we focus on a grid of 28 combinations: 7 leave policies $\times$ 4 tax-transfer policies

National Implementation: Policy Grid

Leave Policies in the Simulation Grid

	Policy ID	Tier 1 Eligibility (hours)	Tier 1 Generosity: Protected (weeks)	Tier 1 Generosity: Paid (weeks)	Tier 1 Generosity: Rate	Tier 2 Eligibility (hours)	Tier 2 Generosity: Protected (weeks)	Tier 2 Generosity: Paid (weeks)	Tier 2 Generosity: Rate	Place-Time
no leave	LP1	0	0	0	0					TX < 93
FMLA	LP2	1250	12	0	0					FL > 93
only paid	LP3	800	0	10	0.67					NJ 79-89
	LP4	400	10	10	0.55					RI 79-86
	LP5	0	6	0	0	1820	12	0	0	WA 90-92
	LP6	800	0	10	0.67	1000	16	10	0.67	NJ 90-08
paid+protected both tiers	LP7	0	6	12	0.55	1250	18	12	0.55	CA 04-17

Tax Policies in the Simulation Grid

	Policy ID	Married: Lump sum ($) π_0^{tax} Base	Married: Lump sum ($) π_0^{tax} n_t	Married: Slope (%) π_1^{tax} Base	Married: Slope (%) π_1^{tax} n_t	Married: Progr. π_2^{tax}	Married: Marginal Rate (%)	Not Married: Lump sum ($) π_0^{tax} Base	Not Married: Lump sum ($) π_0^{tax} n_t	Not Married: Slope (%) π_1^{tax} Base	Not Married: Slope (%) π_1^{tax} n_t	Not Married: Progr. π_2^{tax}	Not Married: Marginal Rate (%)	Place-Time
low child transfers	TP1	-4,158	-275	1.61	-0.020	1.230	29.4	-1,443	-527	2.40	-0.009	1.206	26.7	GA 91-96
	TP2	-7,318	-284	4.92	0.105	1.143	31.1	-1,080	-535	1.07	0.007	1.272	26.1	NM 87-90
high child transfers	TP3	-8,563	-1,575	5.52	0.355	1.156	44.2	-3,018	-2,005	0.90	-0.023	1.319	35.5	CA 68-81
	TP4	-11,668	-1,330	15.8	-0.018	1.059	33.0	-2,771	-731	8.15	0.216	1.103	28.8	WI 02-10

National Implementation: Fertility

Completed Fertility				
	Tax-Transfer Policy			
Leave Policy	TP1	TP2	TP3	TP4
LP1	2.45	2.48	2.64	2.54
LP2	2.33	2.37	2.60	2.50
LP3	2.26	2.31	2.53	2.45
LP4	2.23	2.26	2.48	2.39
LP5	2.24	2.26	2.45	2.36
LP6	2.04	2.08	2.36	2.28
LP7	2.07	2.11	2.38	2.30

Share of New Mothers				
	Tax-Transfer Policy			
Leave Policy	TP1	TP2	TP3	TP4
LP1	0.858	0.862	0.896	0.874
LP2	0.809	0.815	0.877	0.851
LP3	0.810	0.819	0.872	0.854
LP4	0.799	0.807	0.862	0.842
LP5	0.787	0.787	0.832	0.805
LP6	0.730	0.735	0.811	0.785
LP7	0.734	0.742	0.820	0.796

Notes: *Leave Policies*: **LP1**: no-leave; **LP2**: FMLA; **LP3**: one-tier policy with only paid leave; **LP4**: a one-tier policy with both paid and protected leave; **LP5**: two-tier version of FMLA with only protected leave in both tiers; **LP6**: two-tier policy with only paid leave in the first tier and both types in the second tier; **LP7**: two-tier policy with paid and protected leave in both tiers. *Tax-Transfer Policies*: **TP1**: low child transfers, lower marginal tax rate; **TP2**: low child transfers, medium marginal tax rate; **TP3**: High child transfers, high marginal tax rate; **TP4**: High child transfers, medium marginal tax rate.

National Implementation: Completed Fertility

- **Leave policies**
  - All leave policies reduce completed fertility compared to no leave
  - Two-tier policies with both paid and protected leave have the strongest negative effect, reducing fertility by up to 40 children per 100 women
  - Consistent with previous DID findings (FGH, 2024) that protected leave reduces medium-term fertility in the US
- **Tax-Transfer policies**
  - Tax-transfer policies with high child transfers (TP3, TP4) increase completed fertility
  - By up to 32 children per 100 women
- **Policy interaction**
  - Tax-transfer regimes with high child transfers mitigate the negative effects of leave policies on completed fertility

National Implementation: Motherhood Penalty (First Birth)

Labor income ($)

Leave Policy	Tax-Transfer Policy TP1	TP2	TP3	TP4
LP1	-4,061	-4,107	-3,446	-3,454
LP2	-8,005	-7,426	-5,221	-5,276
LP3	-4,715	-4,548	-3,746	-3,652
LP4	-5,350	-5,069	-4,352	-4,197
LP5	-11,858	-11,910	-10,229	-9,833
LP6	-8,900	-8,601	-7,552	-7,341
LP7	-9,700	-9,086	-7,475	-7,314

Participation

Leave Policy	Tax-Transfer Policy TP1	TP2	TP3	TP4
LP1	-0.083	-0.098	-0.119	-0.116
LP2	-0.061	-0.073	-0.116	-0.112
LP3	-0.065	-0.077	-0.101	-0.102
LP4	-0.066	-0.077	-0.104	-0.096
LP5	-0.008	-0.020	-0.085	-0.081
LP6	-0.023	-0.028	-0.063	-0.060
LP7	-0.026	-0.033	-0.097	-0.091

Hours

Leave Policy	Tax-Transfer Policy TP1	TP2	TP3	TP4
LP1	-191	-193	-181	-181
LP2	-317	-310	-259	-258
LP3	-204	-203	-188	-184
LP4	-236	-234	-213	-207
LP5	-348	-359	-358	-352
LP6	-335	-331	-314	-307
LP7	-360	-351	-315	-311

Wages

Leave Policy	Tax-Transfer Policy TP1	TP2	TP3	TP4
LP1	-0.526	-0.583	-0.532	-0.535
LP2	-0.916	-0.873	-0.647	-0.650
LP3	-0.816	-0.796	-0.716	-0.700
LP4	-0.810	-0.801	-0.837	-0.767
LP5	-1.016	-1.146	-1.280	-1.169
LP6	-0.798	-0.854	-1.058	-1.009
LP7	-1.036	-1.010	-1.125	-1.083

Notes: The motherhood penalty of first birth is estimated using an event study specification, accounting for three periods before birth and ten periods after. Penalty computed only for women who were not mothers at the start. *Leave Policies*: **LP1**: no-leave; **LP2**: FMLA; **LP3**: one-tier policy with only paid leave; **LP4**: a one-tier policy with both paid and protected leave; **LP5**: two-tier version of FMLA with only protected leave in both tiers; **LP6**: two-tier policy with only paid leave in the first tier and both types in the second tier; **LP7**: two-tier policy with paid and protected leave in both tiers. *Tax-Transfer Policies*: **TP1**: low child transfers, lower marginal tax rate; **TP2**: low child transfers, medium marginal tax rate; **TP3**: High child transfers, high marginal tax rate; **TP4**: High child transfers, medium marginal tax rate.

National Implementation: Motherhood Penalty

- **Effect of leave policies on the motherhood penalty**
  - All leave policies, especially policies with protected leave, increase the motherhood penalty in labor income, worked hours, and wages
  - Relative to no-leave (LP1) the penalty in
    - labor income ↑ between \$198 (LP3) and \$7,803 (LP5)
    - worked hours ↑ between 3 hours (LP3) and 177 hours (LP5)
    - wages ↑ between \$0.11 (LP2) and \$0.74 (LP5)
    - participation ↓ between 0.3 pp (LP3) and 7.8 pp (LP5)
  - Two-tier policies (LP5-LP7) with low child transfers (TP1, TP2) ↓ participation penalty the most; they give access to mothers with lower labor attachment, fostering post-birth participation

- **Comparison with previous studies**
  - Findings are consistent (even in magnitude to a reasonable degree) with those in FGH (2024), despite not targeting causal effects or even the motherhood penalty itself
  - Extends the causal assessment to FMLA (LP2), FMLA does increase the motherhood penalty but less than two-tier policies

National Implementation: Labor Market Outcomes

Participation Rate

Leave Policy	Tax-Transfer Policy TP1	TP2	TP3	TP4
LP1	0.826	0.790	0.682	0.709
LP2	0.860	0.823	0.707	0.738
LP3	0.842	0.806	0.697	0.722
LP4	0.855	0.820	0.717	0.745
LP5	0.900	0.872	0.781	0.811
LP6	0.900	0.870	0.771	0.800
LP7	0.884	0.852	0.750	0.778

Mean Hours

Leave Policy	Tax-Transfer Policy TP1	TP2	TP3	TP4
LP1	1,929	1,745	1,380	1,487
LP2	2,147	1,948	1,503	1,624
LP3	1,936	1,759	1,399	1,491
LP4	1,971	1,792	1,427	1,535
LP5	2,546	2,356	1,855	1,960
LP6	2,304	2,125	1,706	1,808
LP7	2,265	2,081	1,646	1,751

Mean Wage ($)

Leave Policy	Tax-Transfer Policy TP1	TP2	TP3	TP4
LP1	17.5	16.7	15.2	15.6
LP2	18.7	17.7	15.7	16.3
LP3	18.2	17.3	15.6	16.1
LP4	18.4	17.4	15.7	16.3
LP5	21.1	20.1	17.5	18.0
LP6	20.3	19.2	17.1	17.6
LP7	20.1	19.1	16.8	17.4

Present Value Labor Income (Million $)

Leave Policy	Tax-Transfer Policy TP1	TP2	TP3	TP4
LP1	0.476	0.406	0.253	0.279
LP2	0.622	0.531	0.314	0.348
LP3	0.500	0.428	0.270	0.294
LP4	0.523	0.449	0.287	0.317
LP5	0.967	0.858	0.540	0.580
LP6	0.779	0.687	0.449	0.485
LP7	0.739	0.646	0.407	0.442

Notes: *Share of Years Working* is the total years worked divided by total years in the labor market (from entry to age 64 in simulation). *Present Value* of income is calculated at entry with a 5% interest rate. *Net Income* refers to after-tax household income, excluding single men households. *Leave Policies*: **LP1**: no-leave; **LP2**: FMLA; **LP3**: one-tier policy with only paid leave; **LP4**: a one-tier policy with both paid and protected leave; **LP5**: two-tier version of FMLA with only protected leave in both tiers; **LP6**: two-tier policy with only paid leave in the first tier and both types in the second tier; **LP7**: two-tier policy with paid and protected leave in both tiers. *Tax-Transfer Policies*: **TP1**: low child transfers, lower marginal tax rate; **TP2**: low child transfers, medium marginal tax rate; **TP3**: High child transfers, high marginal tax rate; **TP4**: High child transfers, medium marginal tax rate.

National Implementation: Labor Market Outcomes

- **Effects of leave policies on labor market outcomes of all women**
  - All leave policies boost participation, hours, wages, and income over the life cycle
  - FMLA (LP2) is the most effective one-tier policy, increasing
    - participation by up to 10.2 pp, hours by up to 618 annual hours, wages by up to $3.6
  - Two-tier policies (ex: LP5) create the highest gains
- **Protected leave and human capital**
  - Higher take-up of protected leave in two-tier policies helps maintain human capital, increasing future wages and participation
  - Paid leave without job protection (LP3) yields smallest impacts on labor market outcomes
- **Effects of tax-transfer policies on labor market outcomes of all women**
  - Higher child transfers yield lower labor market outcomes
  - Highest child transfers and marginal tax rates (TP3) reduce labor market outcomes the most
    - Lower marginal utility of consumption
    - Increased substitution of labor income with transfer income over time
    - Effect sustained by adjacent complementarity of leisure

National Implementation: Policy Cost and Tax Revenue

Present Value Protected Income
($ Per Household)

Leave Policy	Tax-Transfer Policy TP1	TP2	TP3	TP4
LP1				
LP2	988	785	300	296
LP3				
LP4	261	238	114	111
LP5	3,087	2,617	1,176	1,145
LP6	2,296	1,976	1,019	994
LP7	2,101	1,778	830	803

Present Value Replacement Income
($ Per Household)

Leave Policy	Tax-Transfer Policy TP1	TP2	TP3	TP4
LP1				
LP2				
LP3	1,396	1,297	986	950
LP4	1,434	1,340	1,005	967
LP5				
LP6	2,837	2,631	1,982	1,909
LP7	2,727	2,524	1,925	1,854

Present Value Tax Revenue
(Million $ Per Household)

Leave Policy	Tax-Transfer Policy TP1	TP2	TP3	TP4
LP1	0.297	0.250	0.280	0.167
LP2	0.336	0.285	0.304	0.187
LP3	0.305	0.258	0.287	0.175
LP4	0.308	0.261	0.292	0.179
LP5	0.441	0.383	0.397	0.260
LP6	0.382	0.330	0.356	0.231
LP7	0.372	0.319	0.339	0.218

Excess Revenue Relative to No-Leave
($ Per Household)

Leave Policy	Tax-Transfer Policy TP1	TP2	TP3	TP4
LP1				
LP2	38,675	34,485	24,008	19,854
LP3	8,239	7,293	7,052	7,152
LP4	10,842	10,609	12,259	12,084
LP5	143,594	132,944	116,446	92,758
LP6	84,665	79,264	75,635	63,306
LP7	75,172	68,871	59,216	50,728

Notes: *Protected Income* is the labor income generated by protected human capital gained through leave. Present value of income is calculated at entry with a 5% interest rate. *Net Income* refers to after-tax household income, excluding single men households. *Leave Policies*: **LP1**: no-leave; **LP2**: FMLA; **LP3**: one-tier policy with only paid leave; **LP4**: a one-tier policy with both paid and protected leave; **LP5**: two-tier version of FMLA with only protected leave in both tiers; **LP6**: two-tier policy with only paid leave in the first tier and both types in the second tier; **LP7**: two-tier policy with paid and protected leave in both tiers. *Tax-Transfer Policies*: **TP1**: low child transfers, lower marginal tax rate; **TP2**: low child transfers, medium marginal tax rate; **TP3**: High child transfers, high marginal tax rate; **TP4**: High child transfers, medium marginal tax rate.

National Implementation: Policy Cost and Tax Revenue

- **Leave policies**
  - All leave policies in the grid increase the government's net revenue relative to no leave
  - By a minimum of $7,052 per household in present value
  - Two-tier policies show the highest gains in tax revenue net of policy cost by retaining more women in the workforce
- **Impact of high child transfers**
  - Tax-transfer regimes with high child transfers reduce the overall tax revenue gains from leave policies
  - This is due to reduced labor market participation as higher transfers allow income substitution, which affects taxable income
- **What explains the net gains from leave policies?**
  - Financial costs of leave policies are fairly temporary, labor market gains are long-term
    - Cost of protected human capital declines quickly with depreciation
    - Cost of paid leave is only faced at the time of birth

Conclusion

- **What we do**
  - Combine extensive quasi-experimental variation on US leave and tax-transfer policies (1968-2017)
  - with a dynamic discrete-continuous choice model of fertility and work (extensive and intensive)
  - Counterfactually implement nationally a grid of 28 policies
  - Prove identification of the utility function
- **Key findings**
  - Labor market vs. fertility: policies that boost women's labor participation (ex: two-tier leave) tend to decrease fertility, while those that increase fertility (ex: high child transfers) often reduce labor market outcomes
  - Balancing policy goals: a combination of two-tier leave with high child transfers offers a balanced approach, enhancing labor market outcomes while only moderately affecting fertility
  - Budget impact: regardless of the tax-transfer arrangement, all leave policies increase government revenue relative to no-leave scenarios
- Our findings highlight potential policy solutions that support women's labor outcomes and the government's budget, while managing the trade-off with fertility outcomes

Appendix: Birth, Income Shocks, and Permanent Income

Dependent variable: Birth at t

	(1)		(2)		(3)		(4)		(5)	
	coef.	se	coef.	se	coef.	se	coef.	se	coef.	se
Non-labor income residual, u^e_{it}	-0.0009	0.0011			-0.0018	0.0011			-0.0017	0.0011
Residual average, $\bar{u}^e_i$			0.0013	0.0008	0.0030	0.0013			0.0028	0.0013
Permanent wages, μ_i							0.0185	0.0009	0.0197	0.0011
Year FE	✓		✓		✓		✓		✓	
Observations	62,647		101,594		62,647		104,803		62,647	

Notes: Set of regressions of birth at t for person i on residual non-labor income and permanent wages. *Rows*: u^e_{it} is the residual non-labor income for person i at time t from the non-labor income process (conditional on having any) estimated in the paper, which includes age, race, education, marital status, spouse education, and year fixed effects. $\bar{u}^e_i$ is the average across periods of u^e_{it} for person i, which approximates permanent non-labor income. μ_i is the measure of permanent wages estimated in the paper. All independent variables are standardized (divided by their standard deviation). All regressions are conditional on $age \leq 45$ and include year fixed effects. The number of observations depends on the availability of each measure: u^e_{it} is available for those who had non-labor income at t, $\bar{u}^e_i$ is available for those who ever had non-labor income in the sample, and μ_i is available for all observations in the sample.

Key takeaways:

- Idiosyncratic non-labor income shocks negatively signed and not significant
- Measures of permanent non-labor income and permanent wage-productivity positively signed and significant

Back to low of motion of savings