The equilibrium effects of state-mandated minimum staff-to-child ratios

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Motivation

- Governments extensively regulate the childcare market with the goal of increasing quality
- Regulating quality directly is hard, so in practice governments regulate inputs instead
- Main input in childcare is labor $\implies$ minimum ratio arguably most important regulation
- Fundamental tradeoff associated to minimum staff to child ratios:
  - They increase quality of childcare, increase price, and reduce quantity Hotz and Xiao (2011)
- **Aggregate** market-level evidence, hard to map to **individual** effects on skills
  - Who are the children who gain/lose skills?
  - Overall effect on skill distribution?
- This uncertainty is probably reflected in policy design:
  - For children younger than 3 yo, range for minimum ratios is 1:4-1:12 Histogram ratios

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  - Endogenizes staffing decisions of childcare providers
    - Efficiency units of lead teacher, adults in classroom
  - Endogenizes the wages of teachers and childcare workers
  - Allows for rich family heterogeneity

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  - Allows for rich family heterogeneity
- Estimate the model combining individual-level data and state-level data

Related literature

- Literature on effects of policies on skills of children
  - EITC (Dahl and Lochner (2012); Mullins (2022)), parent interventions (Sylvia, Warrinnier, Luo, Yue, Attanasio, Medina and Rozelle (2021); Gertler, Heckman, Pinto, Chang, Grantham-McGregor, Vermeersch,Walker and Wright (2021), early childhood programs Heckman, Garcia, Leaf and Prados (2017); Daruich (2018)
  - **Contribution to this literature:** Effects of supply side regulations on skills of children.
- Literature on equilibrium in the childcare market
  - Borowsky, Brown, Davis, Gibbs, Herbst, Sojourner, Tekin and Wiswall (2022); Berlinski, Ferreyra, Flabbi, and Martin (2023); Moschini (2023)
  - **Main contributions to this literature**:
    - First model combining endogenous quality production, skill accumulation, endogenous wages
    - Rich heterogeneity in informal care quality
- Empirical literature on effects of childcare market regulations
  - Chipty (1995); Blau (2003); Currie and Hotz (2004); Blau (2007); Hotz and Xiao (2011)
  - **Contribution to this literature:** Structural model of regulations, first study of mandatory ratios on skills.

Model, Overview

- **Families**
  - Heterogeneous in:
    - Household structure (2 Parents vs 1 Parent)
    - Parenting quality
    - Quality and quantity of care by relatives
    - Initial assets and wages
    - Initial skills of children
  - Choose:
    - Consumption, savings, leisure, labor supply
    - Time in each childcare arrangement, quality and type of paid care

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- **Teachers**
  - Two types: Lead teachers and childcare workers, elastic supply

Families, preferences

- Unitary household formed by mother m, child, maybe father f.
- Three periods: When child is 9 months, 2 years, and 4 years old.

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- Unitary household formed by mother m, child, maybe father f.
- Three periods: When child is 9 months, 2 years, and 4 years old.
- In periods $t = 1, 2, 3$ families derive flow utility according to:

$$\log c_t + \delta_l^m \log l_t^m + \delta_l^f \log l_t^f + \delta_\tau^m \log \tau_t^m + \delta_\tau^f \log \tau_t^f + \delta_{\theta,t} \log \theta_t$$

- The continuation utility at period 4 is given by:

$$V_4(a_4, \theta_4) = \delta_a \log a_4 + \delta_{\theta,4} \log \theta_4$$

  - c: Consumption
  - l^j: Leisure of parent j
  - τ^j: Time with child of parent j.
  - θ_t: Cognitive skills of child
  - a_t: Assets

Families, constraints

- Budget constraint

$$P^D(q_t^P, \tau_t^P) + c_t + a_{t+1} = w^f n_t^f + w^m n_t^m + a_t(1+r)$$

- Paid care is center or home-based

$$D \in \{CB, HB, N\}$$

- Time use constraint for parents

$$l^j + \tau^j + n^j = \overline{T}$$

- Supervision constraint for child

$$\tau^m + \tau^f + \tau^r + \tau^P = \overline{T}$$

Families, Production Function of skills

- Child skills produced according to:

$$\log \theta_{t+1} = \log A_t + \gamma_{\theta,t} \log \theta_t + \gamma_{m,t} \frac{\tau_t^m}{\overline{T}} \log q^m$$
$$+\gamma_{f,t} \frac{\tau_t^f}{\overline{T}} \log q^f + \gamma_{P,t} \frac{\tau_t^P}{\overline{T}} \log q_t^P + \gamma_{r,t} \frac{\tau_t^r}{\overline{T}} \log q_t^r + \eta_{t+1}$$

- In the previous expression:
  - q: Quality
  - A_t: Time varying TFP
  - η_{t+1}: Skill accumulation shock
- Quality of parental time and care by relatives exogenous and heterogeneous across families
- Quality of paid care is endogenous and purchased on the market

Families, utility costs

- Stochastic cost o_t^D of using paid care $D = HB, CB$.
- Drawn in each period by each family
- o_t^{HB} and o_t^{CB} independent from each other and their own leads/lags
- $o_t^D \sim \exp(\lambda_t^D)$

Providers, Production function of quality

- Quality of care produced according to:

$$q_t^D = A_t^D \left(\frac{E_t}{k_t}\right)^{\alpha_{E,t}^D} \left(\frac{C_t}{k_t}\right)^{1-\alpha_{E,t}^D}$$

- Where
  - E: Efficiency units of the lead teacher
  - C: Number of caregivers (includes the lead teacher)
  - k: Children in the classroom, "kids"

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- Where
  - E: Efficiency units of the lead teacher
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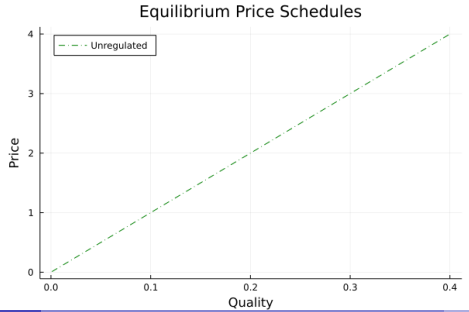
  - k: Children in the classroom, "kids"
- Regulations: Staff-to-child ratio cannot be below minimum regulated:

$$\frac{C_t}{k_t} \geq \underline{R_t^D}$$

Providers, pricing schedule

$$P(q,\tau) = \begin{cases} \overline{P} q \tau \text{ if } q > q^* \\ \left[\underline{P}(\underline{R}) q^{\frac{1}{\alpha_E}} + \kappa_P(\underline{R})\right] \tau \quad \text{if } q \leq q^* \end{cases}$$

- $\frac{\partial \underline{P}}{\partial \underline{R}} < 0$ and $\frac{\partial \kappa_P}{\partial \underline{R}} > 0$ (keeping wages of teachers constant)



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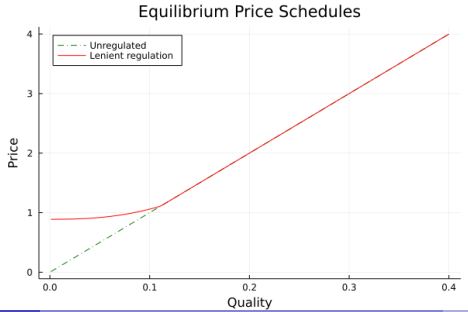

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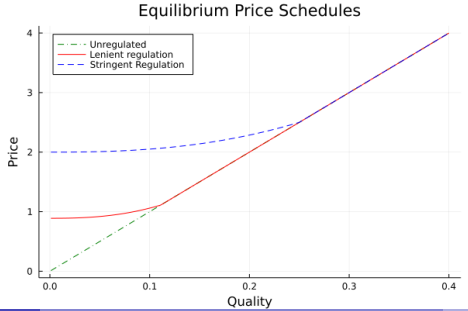

Labor supply of teachers

- Change in regulations $\implies$ Change in $P(q)$ $\implies$ Change in demand for τ^P, q^P $\implies$ Change in E^D, C^D $\implies$ Change in w^E, w^C $\implies$ Change in $P(q)$
- To capture this, elastic supply of labor, elasticity is constant
- Potentially different elasticity for lead teachers and childcare workers

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  - Time of child in each childcare arrangement, quality, and price
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Identification of parental care quality distribution

- Heterogeneity in observed and unobserved informal quality of arrangements has been hypothesized key to rationalize effects on skills of childcare programs
  - Kline and Walters (2016), Kottelenberg and Lehrer (2017), Cornelissen, Dustmann, Raute, Schönbergh (2018), Fort, Ichino, Zanella (2020)
- Here, quality is measured using a battery of survey questions about and direct observations of child-caregiver interactions and attitudes
- Measurement system:

$$\widetilde{\log q}^{j,s} = \mu^{j,s} + \alpha^{j,s} \log q^{j} + \epsilon^{j,s} \ , \ j = m, f \ , \ s = 1, 2$$

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- Measurement system parameters identification:
  - Standard, 2 measures + instrument

Details measure construction

Identification of parental care quality distribution

- Split parental quality in observable and unobservable component:

$$\log q^j = X'_{j,q}\beta_{j,q} + \nu_{j,q} := \log q^{j,e} \ ,$$

$$\begin{pmatrix} \nu_m \\ \nu_f \end{pmatrix} \sim \mathcal{N}\begin{pmatrix} \sigma^2_{\nu,m} & \rho_{\nu,m,f}\sigma_{\nu,m}\sigma_{\nu,f} \\ \rho_{\nu,m,f}\sigma_{\nu,m}\sigma_{\nu,f} & \sigma^2_{\nu,f} \end{pmatrix}$$

- Identification:
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- Identification:
  - $\beta_{j,q}$: Covariation of $\widetilde{\log q}^{j,1}$ and observables
  - Variance/covariance of ν_j: Covariance of residuals
- Estimates for $\beta_{j,q}$ tell us that:
  - Higher wage and more educated parents more effective at fostering skill development
  - Parents with better relatives available are better parents themselves

Parenting quality: Assortative mating in observables and unobservables

Table: Parameter estimates for the joint distribution of parental care unobservables

$\sigma^2_{\nu,m}$	$\sigma^2_{\nu,f}$	$\rho_{\nu,m,f}$
0.04	0.18	0.74
(0.01)	(0.2)	(0.56)

Table: Statistics of the joint distribution of $\log q^{m,e}, \log q^{f,e}$

$Var(\log q^{m,e})$	$Var(\log q^{f,e})$	$corr(\log q^{m,e}, \log q^{f,e})$
0.03	0.06	0.68

- Assortative mating in parenting quality
- Paternal quality has higher variance

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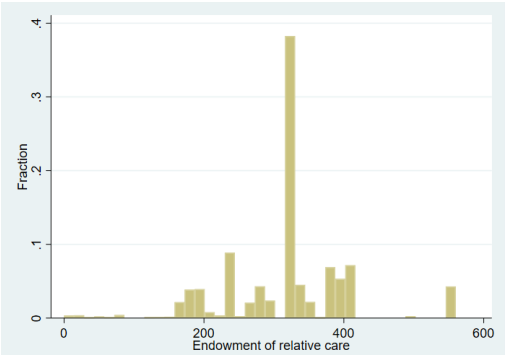
- This is true if:
  - q^m, q^f not bounded away from zero
    - This implies that some parents don't want to spend time with their children
    - True in the quantitative application by distributional assumptions
  - Costs support in $(0, \infty)$
    - Implies some parents want to avoid paid care no matter how rich
    - True from the exponential assumption

Availability of care provided by relatives is very heterogeneous

$$Z^{T,r} = (\text{Grandmother age}, \text{Grandfather age}, \text{Number adults HH})$$

- Distribution of available hours of care by relatives per month:



Importance of lead teacher efficiency units in production increases with age

- Optimality for unrestricted providers:

$$\alpha_{E,t} = \frac{w^E E}{w^E E + w^C C}$$

$\alpha_{E,1}$	$\alpha_{E,2}$	$\alpha_{E,3}$
0.093	0.14	0.24
-	(0.0080)	(0.0056)

- Lead teacher wages not observed at $t = 1$, so I extrapolate $\alpha_{E,1}$

Production function of cognitive skills and relative care quality location

- Combining the linear Measurement System with the Production Function for skills:

$$\widetilde{\log \theta}^1_{t+1} = \log A_t + \gamma_{\theta,t}\widetilde{\log \theta}^1_t + \gamma_{par,t}\left(\frac{\tau^m_t}{\overline{T}}\frac{\widetilde{\log q}^{m,2} - \mu^{m,2}}{\alpha^{m,2}} + \frac{\tau^f_t}{\overline{T}}\frac{\widetilde{\log q}^{f,2} - \mu^{f,2}}{\alpha^{f,2}}\right) +$$

$$\frac{\gamma_{nonpar,t}}{\alpha^{ARNETT}_t}\left(\frac{\tau^p}{\overline{T}}\widehat{ARNETT}^p_t + \frac{\tau^r}{\overline{T}}\widehat{ARNETT}^r_t\right) - \frac{\gamma_{nonpar,t}}{\alpha^{ARNETT}_t}\frac{\tau^r_t + \tau^p_t}{\overline{T}}\mu^{ARNETT}_t + \text{composite error}$$

Identification Arnett factor loading

- The term in red captures comparison between average relative and parental quality
- Other than that, standard identification of production functions with latent inputs.

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- Two-step estimation procedure:
  - 1st step: Leverage restrictions from FOC and observed choices using minimum distance:
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  - Updating $\{\delta_{\theta,t}\}_{t=1}^3$ important to match bunching at minimum ratio and hours of paid care
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- Estimation results:
  - Parents value leisure, time with their child, skills of their child
  - Maternal time with child more valued than paternal time with child

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- Labor supply shifters: Model-predicted labor demand+ observed wages
  - Estimation: Compute model-predicted labor demands under observed wages, solve for shifters
  - Allows to match wages of teachers and childcare workers...
  - ... without solving for equilibrium wages repeatedly

Expressions shifters

Results

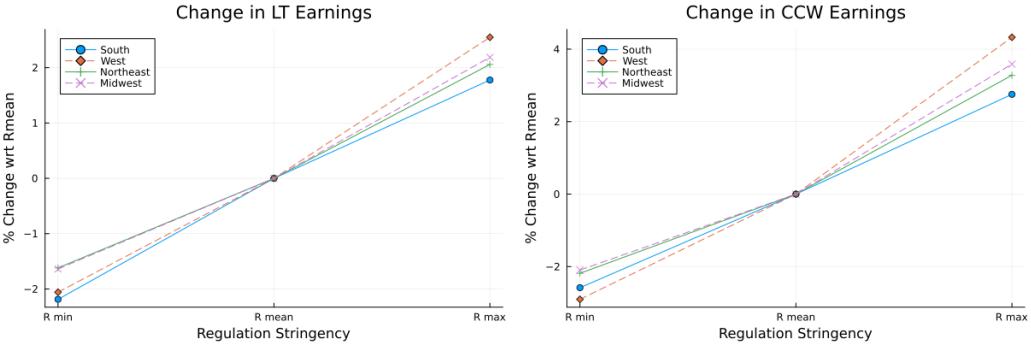
- Solve model using estimated parameters for three scenarios Details:
  - Least stringent regulation
  - Average regulation
  - Most stringent regulation
- Study effects of stringency on:
  - Teacher wages
  - Distribution of skills
  - Family characteristics of skill gainers and losers

Aggregate effects

	Two-Parent	Single Mothers
$\Delta\tau_1^P$	-102	-544
$\Delta\tau_2^P$	-130	-332
$\Delta\tau_3^P$	-30	-88
$\Delta \log q_1^P$	0.02	0.89
$\Delta \log q_2^P$	0.21	0.86
$\Delta \log q_3^P$	0.69	1.11
Δn^m	-38	-187

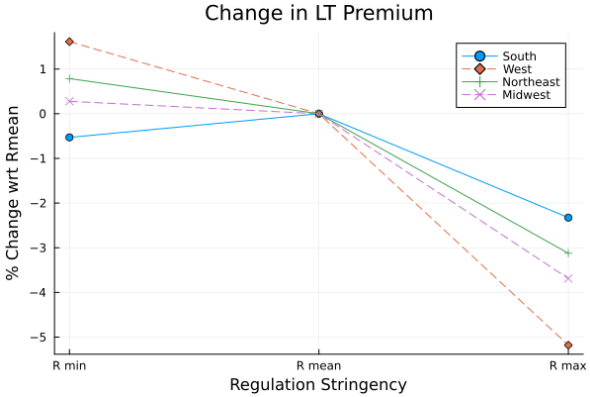
- More stringent regulations increase quality but decrease quality of paid care
  - Consistent with Hotz and Xiao (2011)
- Labor supply of mothers decreases
- Effects more pronounced for Single Mothers

Effects on teachers' wages (GE effect)



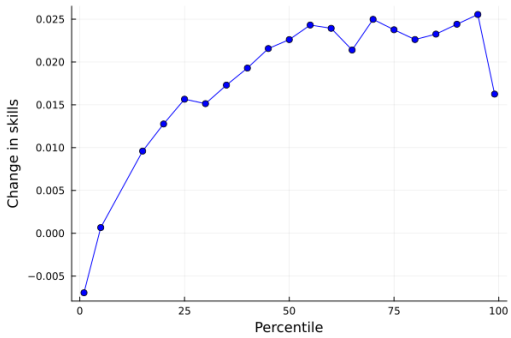
- ↑ stringency $\implies$ ↑ teacher's wages (quantitative, not theoretical result).
- Not negligible impact
- Some heterogeneity by region (due to different family heterogeneity).

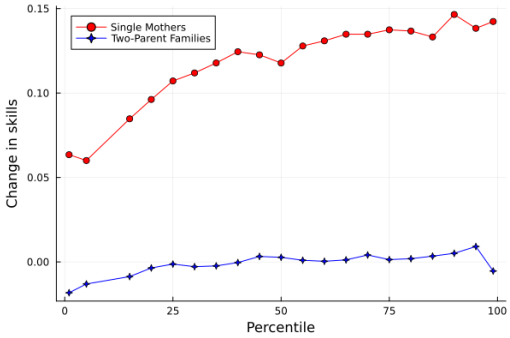
Effects on Lead Teacher Premium



- Note: The lead teacher premium is the factor price of the lead teacher's efficiency units

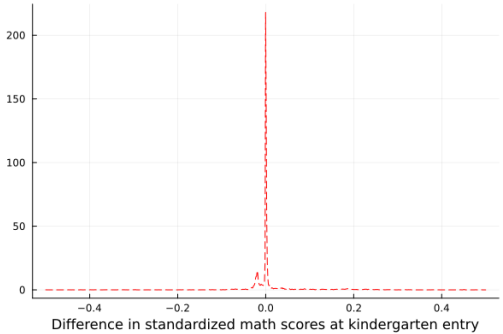
Effects on the skill distribution

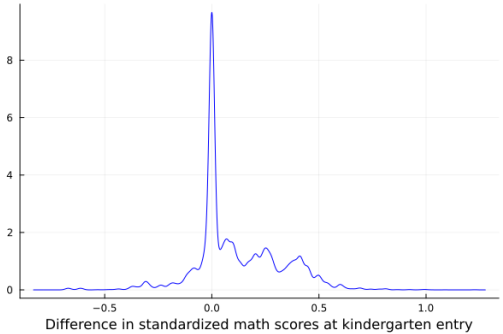




- With more stringent staff-to-child ratios:
  - Overall distribution: Skill increases for most percentiles
  - More pronounced effects for children of Single Mothers

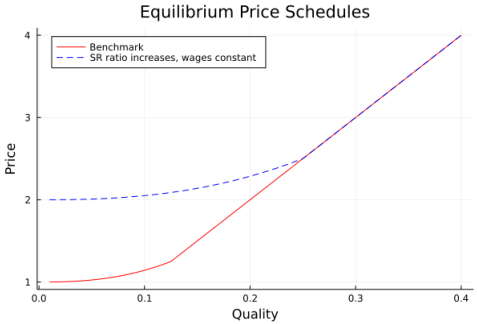
Skill gainers and losers





- Children of Single mothers more affected by change in stringency
- Large gains for some children, large losses for others

Price schedule and problem of the family



- ↑ Price $\Longrightarrow$ families reduce paid care $\Longrightarrow$ skill losses
- Flattening of price schedule $\Longrightarrow$ families that stay buy higher quality $\Longrightarrow$ skill gains
- Response depends on substitution possibilities: Availability of relative care and assets
- Poorer families buy lower quality $\Longrightarrow$ more exposed

Family characteristics of skill gainers and losers (SM families)

- Big skill gainers born to poorest mothers who cannot substitute paid care
- Big skill losers born to moderately poor mothers with low quality informal options
- Moderate skill losers: Born to richer mothers

	Big skill losses	Moderate losses	Moderate gains	Big skill gains
Initial net worth ($)	14400	204600	29600	9500
Mother's wage ($/hour)	10	12	10	9
Maternal care quality	-0.21	-0.10	-0.08	-0.11
Relative care quality	0.07	0.76	0.83	0.67
Hrs/week relative care	4377	4600	3850	2417

Characteristics of TP families

Choices winners and losers

- Big skill gainers: Don't substitute away from paid care, buy higher quality
- Big skill losers:
  - Rely heavily on paid care in benchmark
  - Large substitution after regulation becomes stringent

Choices of winners and losers for SM families

	Big skill losses	Moderate losses	Moderate gains	Big skill gains
$\Delta\tau^P$	-2138	-595	-235	17
$\Delta\tau^r$	1563	219	56	-207
$\Delta\tau^m$	574	375	179	190
$\Delta \log q_2^P$	0.64	0.64	0.86	1.32
$\log q_2^P(R_{min})$	1.12	1.15	1.07	0.74
$\tau^P(R_{min})$	3042	1484	2186	3755

Choices of TP families

Conclusions

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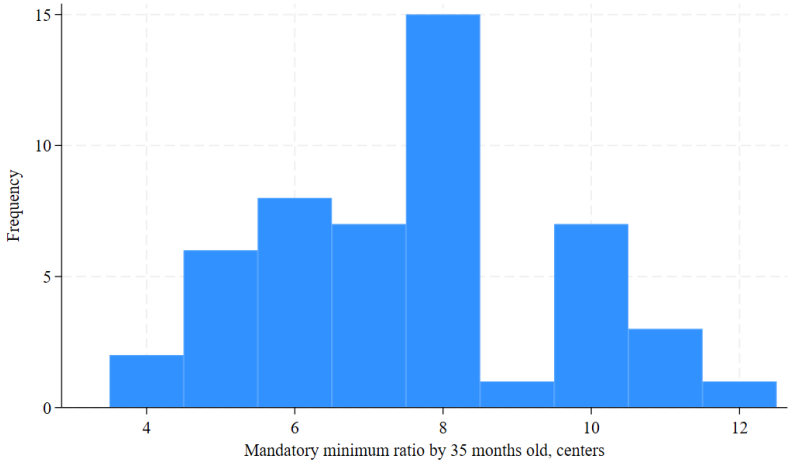
- Future research:
  - Interaction of regulation and subsidies
  - Equilibrium effect of public programs expansion (i.e. Head Start)

Thank You!

Regulations across states



Back

Market failures

- Incomplete markets
  - Borrowing constraints against future parental income
    - Caucutt and Lochner; Lee and Seshadri (2019); Daruich(2018)
  - Borrowing constraints against future income of child
    - Loury (1981); Baland and Robinson (2000) ; Daruich (2018)
- Externalities:
  - Innovation
    - Bell, Chetty, Jaravel, Petkova and Van Reenen
  - Crime
    - Cunha, Heckman, and Schennach (2010); Attanasio, Cardona Sosa, Medina, Meghir, Posso-Suárez (2021)
- Inaccurate parental beliefs
  - Cunha, Elo, Culhane; Attanasio, Boneva, and Rauh (2020)

Back

Price constant expressions

$$\overline{P} = \left[w^E \left(\frac{\alpha_E}{1-\alpha_E} \frac{w^C}{w^E} \right)^{1-\alpha_E} + w^C \left(\frac{1-\alpha_E}{\alpha_E} \frac{w^E}{w^C} \right)^{\alpha_E} \right] \frac{1}{A}$$

$$\underline{P} = w^E \left(\frac{1}{\underline{R}_I} \right)^{\frac{1-\alpha_E}{\alpha_E}} \left(\frac{1}{A} \right)^{\frac{1}{\alpha_E}}$$

Back

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- For father, only survey questions
  - Read books to child (+), Spank child (-), Feel trapped by parenthood (-), etc

Back

Identification of Arnett score factor loading

- Remember the Production Function of quality for paid providers:

$$q_t^P = A_t^P \left(\frac{E_t}{k_t}\right)^{\alpha_{E,t}^P} \left(\frac{C_t}{k_t}\right)^{1-\alpha_{E,t}^P}$$

- Taking logs and substituting the measurement system in:

$$ARNETT = \mu^j + \alpha^j \log A_t^P + \alpha^j \left(\alpha_{E,t} \log\left(\frac{E_t}{k_t}\right) + (1-\alpha_{E,t}) \log\left(\frac{C_t}{k_t}\right)\right) + \epsilon_t$$

- Intuition: Cobb-Douglass + constant returns to scale $\implies \frac{\Delta \log q}{\Delta \text{Inputs}} = 1$
- If $\frac{\Delta Arnett}{\Delta \text{Inputs}} = 2 \implies \frac{\Delta Arnett}{\Delta \log q} = 2$

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Regulation stringency

Table: Least, average, and most stringent regulations across ages and types of care

	18 months old	3 years old	4 years old
Least stringent, Centers	9	15	20
Least stringent, Homes	10	15	18
Average, Centers	5.28	10.7	12.41
Average, Homes	4.60	6.90	7.07
Most stringent, Centers	3	7	8
Most stringent, Homes	2	3	3

- I report child-to-staff instead to staff-to-child for ease of interpretation
- Regulations become less stringent with age.

Back

Identification $\lambda^{CB}, \lambda^{HB}$

- The probability of not choosing paid care is given by:

$$\mathbb{P}(D_t = N|a_t, H) = e^{-\lambda_{CB}(\tilde{V}_t^{CB}(a_t,H)-\tilde{V}_t^{N}(a_t,H))} e^{-\lambda_{HB}(\tilde{V}_t^{HB}(a_t,H)-\tilde{V}_t^{N}(a_t,H))}$$

- It can be shown that:

$$\frac{\partial \mathbb{P}(D_t = HB|a_t, H)}{\partial \lambda_{HB}} \geq 0$$
$$\frac{\partial \mathbb{P}(D_t = HB|a_t, H)}{\partial \lambda_{CB}} \leq 0$$

- Both inequalities strict if CB, HB strictly preferred to N absent utility costs
- Strict monotoniticty $\implies$ λ_3^{CB}, λ_3^{HB} identified from choice probabilities for CB, HB
- $\lambda_t^{CB}, \lambda_t^{HB}$: Same argument + backward induction

Back

Identification δ_θ

- $\Delta_3^{p,r}$: Change in skills at $t = 4$ when reallocating from relatives to paid care at $t = 3$
- Optimality condition for interior τ^P when care by relatives is interior:

$$\underbrace{\beta\delta_{\theta,4}\Delta_3^{p,r}}_{\text{Gain of reallocating from } \tau^r \text{ to } \tau^P} = \underbrace{\frac{P_3(q_3^P)}{c_3}}_{\text{Cost of reallocating from } \tau^r \text{ to } \tau^P} \quad \text{if } \tau^P > 0, 0 < \tau^r < \overline{T}^r$$

- Re-arranging and taking conditional expectations:

$$\beta\delta_{\theta,4} = \frac{\mathbb{E}[\tilde{P}_3 | \tau^P > 0, 0 < \tau^r < \overline{T}^r]}{\mathbb{E}[\Delta_3^{p,r}\tilde{c}_3 | \tau^P > 0, 0 < \tau^r < \overline{T}^r]}$$

- $\tilde{P}$ and $\cdot\tilde{c}$ denote noisy measures of prices and consumption

Back

Identification of δ_τ^m

- $\Delta_\theta^{m,r}$: Change in skills when reallocating from relatives to mother
- Optimality condition for maternal care when care by relatives is interior:

$$\underbrace{\frac{\delta_\tau^m}{\tau^m} + \beta \Gamma_{t+1}^\theta \Delta_\theta^{m,r}}_{\text{Benefit of reallocating from relative to mother}} = \underbrace{\frac{\delta_l^m}{l^m}}_{\text{Cost of reallocating from relative to mother}} \quad \text{if } 0 < \tau^r < \overline{T}^r$$

- Γ_t^θ: Reduced form, captures flow + expected discounted value of skills.
- Re-arranging and taking conditional expectations:

$$\frac{\delta_\tau^m}{\delta_l^m} = \mathbb{E}\left[\frac{\tau_{i,t}^m}{l_{i,t}^m} | 0 < \tau_{i,t}^r < \overline{T}_i^r\right] - \frac{\beta \Gamma_{t+1}^\theta}{\delta_l^m} \mathbb{E}[\tilde{\Delta}_{\theta,i,t}^{m,r} \tau_{i,t}^m | 0 < \tau_{i,t}^r < \overline{T}_i^r] \ .$$

- $\tilde{\Delta}_{\theta,i,t}^{m,r}$ denotes a noisy measure of $\Delta_{\theta,i,t}^{m,r}$ Back

Labor supply shifters expressions

$$\log\left(\overline{H}_{LT}\overline{LT}\right) = \mathbb{E}[\log E^D(w^E, w^C)] - \eta_{LT}\mathbb{E}[\log(w^E + w^C)]$$

$$\log\left(\overline{H}_{CCW}\overline{CCW}\right) = \mathbb{E}\left[\log\left(E^D(w^E, w^C) - C^D(w^E, w^C)\right)\right] - \eta_{CCW}\mathbb{E}[\log w^C]$$

Back

Computational tractability

- Rich heterogeneity, 2 dynamic states, 11 choices, 6 price functions, 2 scalar prices

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- GE: $P(q)$ can be written in closed form given wages.
  - From solving 2 wages and 6 functions to only solving for 2 wages

Family characteristics of skill gainers and losers (TP families)

	Big losses	Moderate losses	Moderate gains	Big gains
Initial net worth ($)	270700	400900	157000	130000
Mother's wage ($/hour)	16	18	14	15
Father's wage ($/hour)	17	22	19	12
Maternal care quality	-0.03	0.05	0.04	-0.02
Paternal care quality	-0.16	-0.04	-0.02	-0.14
Relative care quality	0.57	1.18	1.21	0.46
Hrs/week relative care	3935	4012	4040	3281

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Choices of winners and losers (TP families)

	Big losses	Moderate losses	Moderate gains	Big skill gains
$\Delta\tau^P$	-1635	-31	-10	-2
$\Delta\tau^r$	1223	19	-14	-30
$\Delta\tau^m$	397	11	23	24
$\Delta\tau^f$	15	1	1	8
$\Delta \log q_2^P$	0.38	-0.02	0.31	0.55
$\log q_2^P(R_{min})$	2.14	2.83	2.04	1.73
$\tau^P(R_{min})$	2590	942	369	3388

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