The Fiscal and Welfare Effects of Policy Responses to the COVID-19 School Closures

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Motivation: School Closures in the U.S.

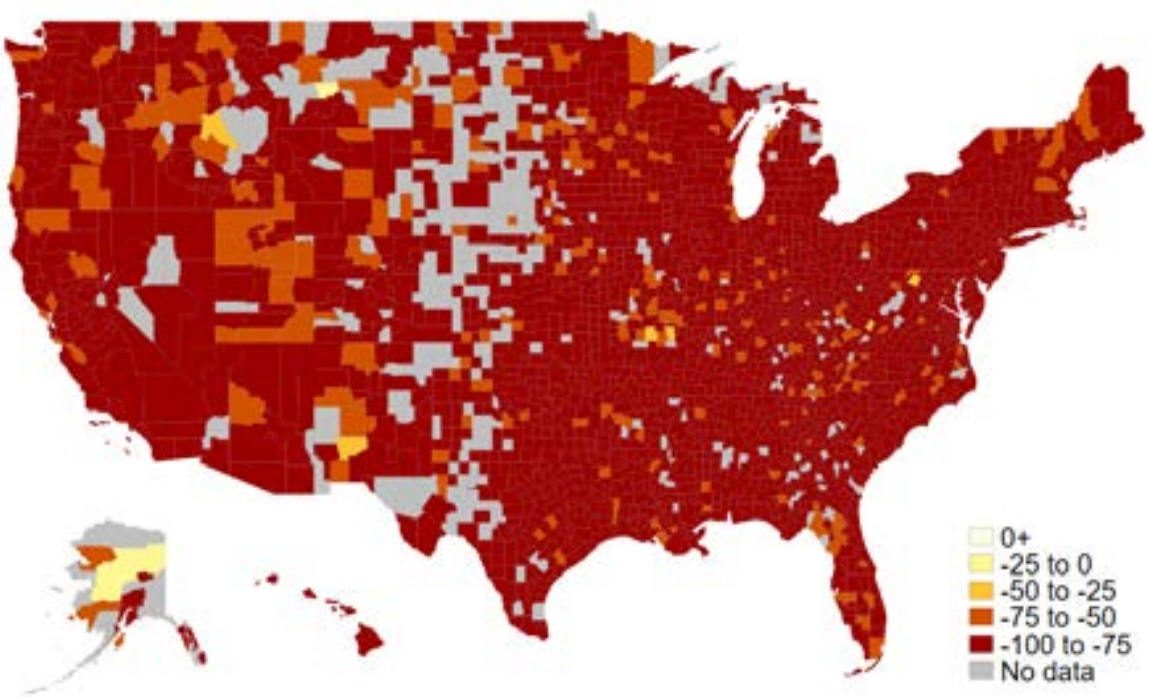


Figure: Avg. change (from 2019) in school visits by county: March-May 2020

- Most schools closed in spring of 2020
- Massive loss of instructional time

Motivation and Research Questions

- Covid-19 Pandemic: Policy responses
  - Lockdown of the economy: Large academic literature
  - School closures: Initially less of a focus (since main costs only accrue in the long run?)
- Our research questions:
  - What are the long-run effects of school closures on
    - ⋆ School children? Average future earnings, welfare. Distributions?
    - ⋆ Public finances?
  - Desirable schooling policy responses?

Research Approach

- Data: Use cell phone data on school visits (Safegraph) and school closures (Burbio) to estimate effective schooling time in 2020-21
  - Data at the school level: public/private, elementary/secondary, schools in poor/rich counties.
- Model: Feed empirical school closure measures into life cycle model with endogenous child human capital accumulation:
  - Child human capital production depends on schooling inputs, parental time and monetary investments.
  - Human capital at age 16, parental transfers determine higher education choice, future earnings.
  - Covid-19: temporary reduction in schooling input (heterogeneous by school type, age of child, income of parents)
  - Model predicts average losses and its distribution in PDV of earnings, welfare from Covid-19 school closures.
- Policy Experiment: Keep schools open during next summers

Key Results

- Data:
  1. On average, schools were effectively closed for 41% (20%) of IV.2019-III.2021 (depending on effectiveness of online learning)
  2. Heterogeneity: Private/primary schools closed less than public/ secondary schools. Higher-income counties closed schools for longer
- Model:
  1. PDV of future earnings fall by 1.7%; welfare losses (CEV) 1%.
  2. Secondary schools closed 20% longer than primary schools ⇒ Children starting secondary school endure largest losses
  3. Private schools closed less ⇒ Increases inequality since private schools attended by richer children
  4. Public schools in poorer areas closed less ⇒ Reduces welfare gap between top-bottom income quartile children by 1/3
- Policy Experiment:
  1. Extending school by 6 weeks in next two summers generates welfare gains for children, future tax revenue makes policy self-financing

Related Literature

- Very large literature on the economic and health impacts of COVID-19 lockdowns...
  - Studies on optimal lockdown policies (but school closures $\notin$ lockdown): Argente et al.(2020), Acemoglu et al. (2020), Glover et al. (2021), Brotherhood et al. (2020)
- Literature on structural modeling of human capital accumulation following Cunha et al. (2006), Cunha and Heckman (2007), Cunha et al. (2010)
  - Applications to the COVID-19 school closures: Agostinelli, Doepke, Sorrenti and Zilibotti (2020), Jang and Yum (2021)
- Studies using Safegraph data on school visits (but focus on spread of COVID-19): Chernozhukov et al. (2021), Bravata et al. (2021)

Data

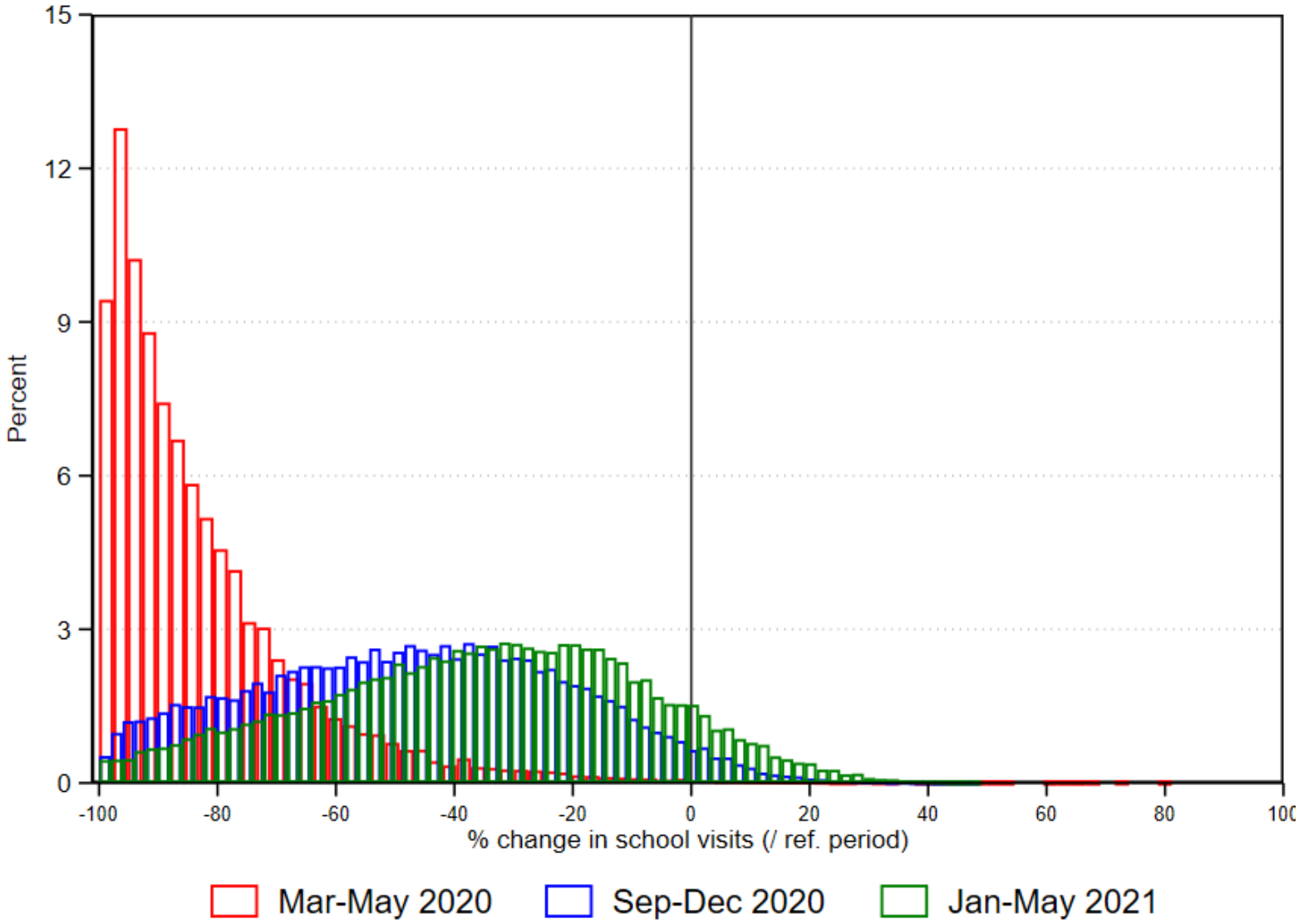
Measuring Extent and Distribution of School Closures

- Weekly visits constructed from cell phone data from Safegraph to elementary and secondary Schools $\sim$ 125K locations
- Match to National Center for Education Statistics data $\Rightarrow$ (Universe of the $\sim$ 100K public schools) and Private School Survey $\Rightarrow$ (representative survey of the $\sim$ 30K private & religious schools).
- Final data set is representative of the full set of elementary and secondary schools in the U.S.
- Measure change in school j visits relative to pre-Covid average:

$$d_{j,t} = \frac{v_{j,t} - \overline{v}_{j,0}}{\overline{v}_{j,0}} \times 100$$

  - $v_{j,t}$ = counts of visits to school j during week t (norm. by county-level counts of Safegraph devices)
  - $\overline{v}_{j,0}$ = average of $v_{j,t}$ from November 2019 through February 2020

Distribution of Changes in School Visits (Rel. to 2019)



School Closures in the U.S. in 2020

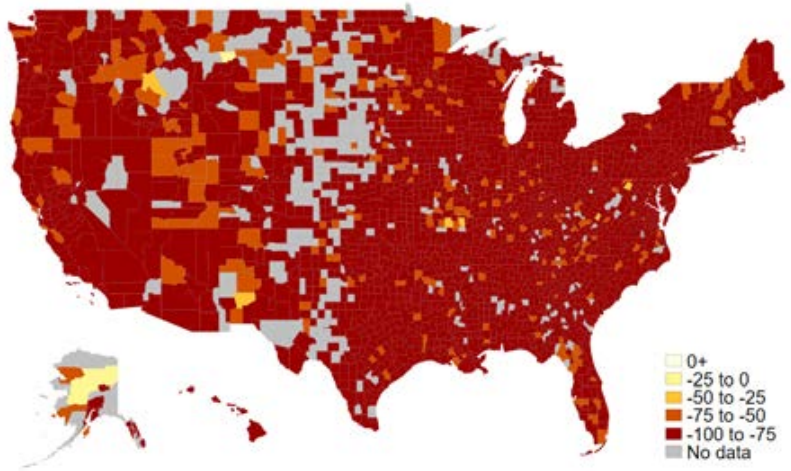


Figure: Avg. change (from 2019) in school visits by county: March-May 2020

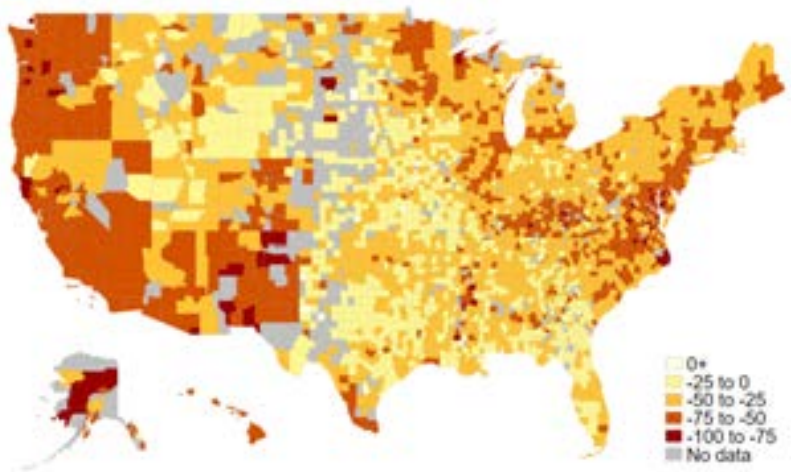


Figure: Avg. change (from 2019) in school visits by county: Sept.-Dec. 2020

Mapping School Visits into Schooling Time

- Construct fraction of school year from Burbio school tracker data that a county spends in traditional, hybrid, online learning mode.
- Estimate mapping between school visits from Safegraph and Burbio learning mode lengths at the county level.
- Use regression coefficients (and assumption on relative productivity on virtual learning) to construct effective schooling time at the individual school level between September 2019 and August 2021 (as share of 72 school weeks over two-year period).
- Share of schooling time missed is the crucial input for model-based thought experiments.

Estimates of Effective Schooling Time (Share of Total, over 2 School Years)

	Without virtual learning		
	All	**Elementary**	**Secondary**
All	**59.2**	**62.2**	**52.3**
Public schools	**58.5**	62.0	51.7
Private schools	**65.9**	66.2	62.1
	All	**Elementary**	**Secondary**
Top 25% inc.	**54.5**	58.0	46.8
Bot. 25% inc.	**63.9**	66.6	58.2

- If virtual instruction is 50% as effective as in-person, similar qualitative patterns but differences become smaller.

Quantitative Model

Based on Fuchs-Schündeln, Krueger, Ludwig and Popova (2021)

Economic Model: Overview

- One parent generation and one child generation, living through full life cycle in partial equilibrium
- When children are part of the household, parents make all economic decisions, including
  - Whether to send child to public or private school
  - Private resource and time investment into school children
  - Inter-vivos transfers
- Child human capital accumulation depends on parental and schooling inputs
- Equipped with human capital and inter-vivos transfers an adolescent decides on higher education (high-school, college)
- Covid-19 school closures: decline in school input measured in data

Individual State Variables (Household Heterogeneity)

State Var.	Values	Interpretation
k	$k \in \{ch, pa\}$	Generation
m	$m \in \{si, ma\}$	Marital Status
j	$j \in \{0, 1, \ldots, J\}$	Model Age
a	$a \geq -\underline{a}(j, e, k)$	Assets
s	$s \in \{pu, pr\}$	School Type
h	$h \geq 0$	Human Capital
e	$e \in \{no, hi, co\}$	Tertiary Education
η	$\eta \in \{\eta_l, \eta_h\}$	Pers. Prod. Shock
ε	$\varepsilon \in \{\varepsilon_l, \varepsilon_h\}$	Trans. Prod. Shock

Individual Choices

Dec. Var.	Values	Decision Period	Interpretation
c	$c > 0$	$j \geq j_a$	Consumption
a'	$a' \geq -\underline{a}(j, e, m, k)$	$j \geq j_a$	Assets
s	$s \in \{pu, pr\}$	$j = j_f$	School Type
i^t	$i^t \geq 0$	when child in hh	Time Investment
i^m	$i^m \geq 0$	when child in hh	Resource Investment
b	$b \geq 0$	$j = j_f + j_a$	Inter-vivos Transfer
e	$e \in \{no, hi, co\}$	$j = j_a$	Tertiary Education

Model in a Nutshell (I): Life-Cycle of Parents

Initial Distribution

$\Phi(m,e,a)$

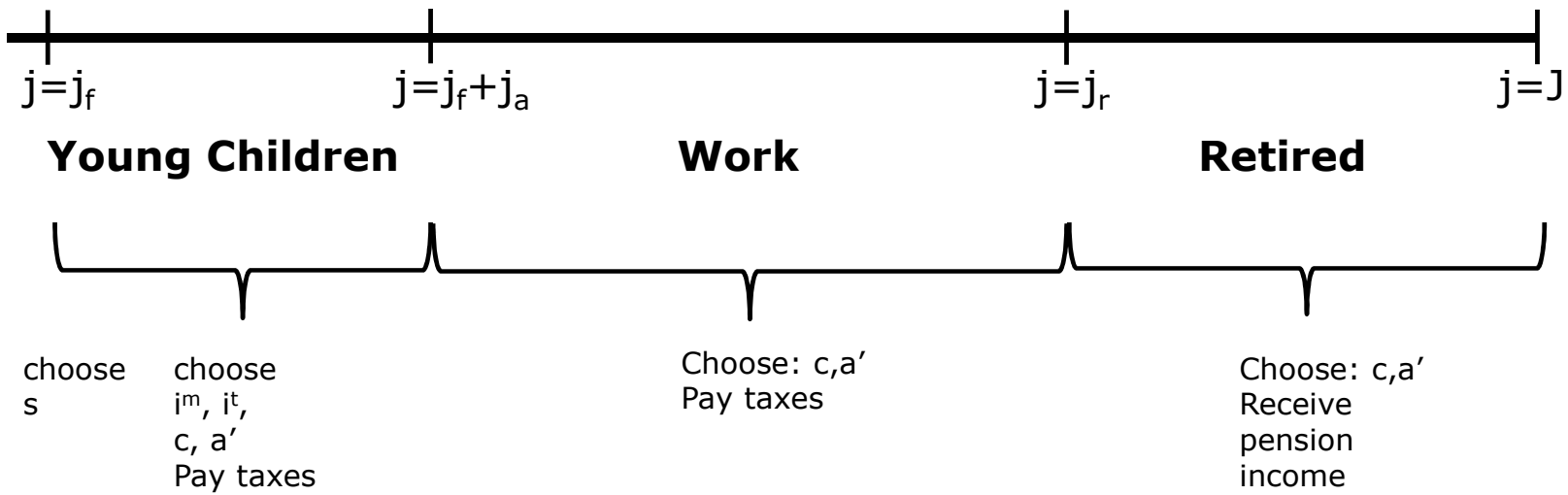
Children Leave Household

Pay inter-vivos transfers b

Earnings while Working

wage w ϵ η ε until retirement
working time l(m) depends on marital status

ϵ = age and educ. specific wage profile
η = persistent productivity shock, 2-state Markov
ε = transitory productivity shock



Model in a Nutshell (II): Life-Cycle of Children

Birth

Innate ability: $h = h_0(m_p, e_p)$

Higher Education?

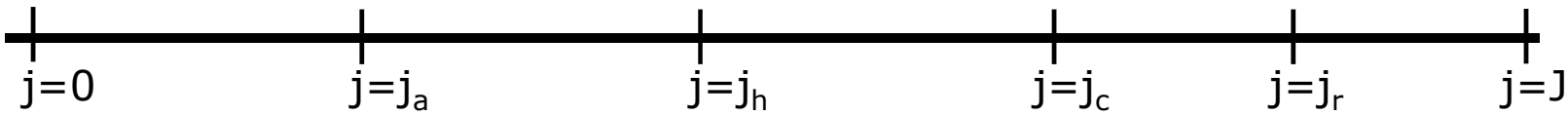
At age j_a given h
i) parents pay inter-vivos transfers
ii) children make higher education decision, with psychological costs $p(s,e,h,e_p)$

Choice: $e=(no,hs,co)$?

Earnings while Working

wage $w\,\gamma(h)\,\epsilon\,\eta\,\varepsilon$ until retirement
working time $l(s)$ after completed education
reduced working time during education

$\gamma(h)$ = fixed effect
ϵ = age and educ. specific wage profile
η = persistent productivity shock, 2-state Markov
ε = transitory productivity shock



Childhood | **High-School** | **College** | **Work** | **Retired**

Receive: i^m, i^t and i^s

Given psychological costs $p(s,hs,e_p,h)$ and wage, choose a',c. Pay taxes

Given psychological costs $p(co,e_p,h)$, tuition, and wage, choose a',c. Pay taxes

Choose: c,a' Pay taxes

Choose: c,a' Receive pension income

Human Capital Production Function for Children

- Human capital accumulation during childhood

$$h' = g(j, s, h, i)$$
$$i = i(i^m, i^t, i^s)$$

  j: age; s: school type; h: human capital

  i^m: parental resource investment; i^t: parental time investment

  i^s: schooling

- Properties of $g(\cdot)$ (Cunha and Heckman, 2007)
  - Multiple nests with imperfect substitutability between h, i^m, i^t, i^g.
  - Self-productivity of human capital: $\frac{\partial h'}{\partial h} = \frac{\partial g(j,s,h,i)}{\partial h} > 0$.
  - (Dynamic) complementarity between h and i: $\frac{\partial^2 g(j,s,h,i)}{\partial h \partial i} > 0$.
- Human capital h at age 16 affects:
  - Psychological cost of higher education $p(s, e, e_p, h)$
  - Individual permanent labor productivity $\gamma(e, h)$

Calibration

Calibration/Estimation: Initial Human Capital

- Distribution $\Phi(m_p, e_p, a)$ of parents comes directly from PSID:
  - marital status: $m_p \in \{si, ma\}$
  - education: $e_p \in \{no, hs, co\}$
  - asset quintiles: a

  with $\xi(m_p, e_p)$ children.
- Initial human capital of children:

$$h_0 = \Phi(e_p, m_p)$$

  set to match PSID-CDS letter word test scores at age 4

Initial Human Capital

Marital Status and Educ of HH Head	Avg. Score	Fraction of $\bar{h}_0$
Single Low	35	0.843
Single Medium	38	0.906
Single High	46	1.107
Married Low	39	0.945
Married Medium	41	0.984
Married High	45	1.085

- h_0 increasing in parental education
- h_0 lower for single parents (exception: $e_p = co$ parents)

Human Capital Process: Three Layers, Ages 4-14

$$h'(h, i; j) = [\mathbf{h}]^{\kappa_j^h} \, [\mathbf{i}]^{(1-\kappa_j^h)}$$

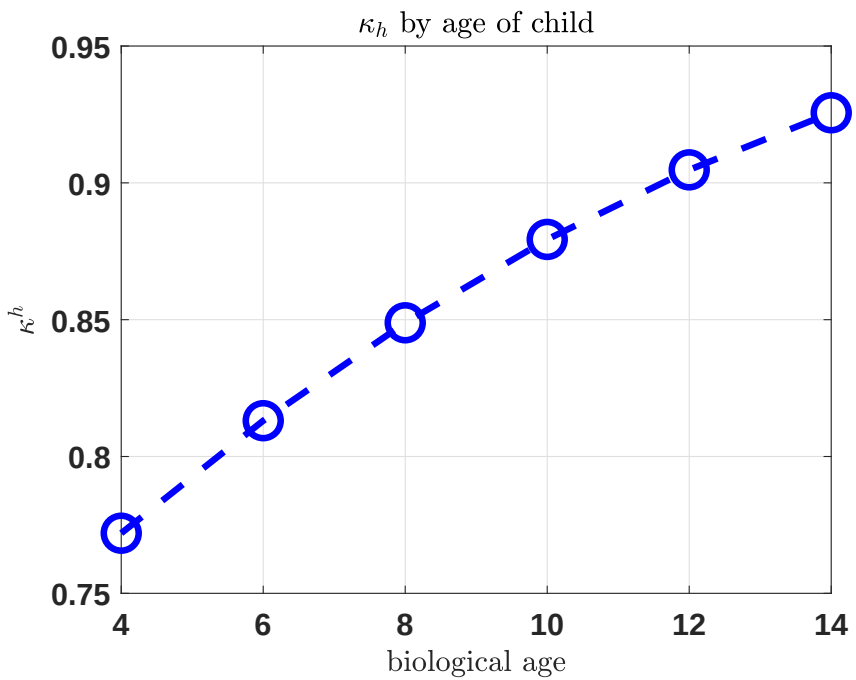
$$\mathbf{i}(\mathbf{i^s}, \mathbf{i^p}; \mathbf{j}) = \bar{A} \left(\kappa_j^s \, [\mathbf{B^s i^s}]^{1-\frac{1}{\sigma^s}} + (1 - \kappa_j^s) \, [\mathbf{i^p}]^{1-\frac{1}{\sigma^s}} \right)^{\frac{1}{1-\frac{1}{\sigma^s}}}$$

$$\mathbf{i^p}(\mathbf{i^m}, \mathbf{i^t}; \mathbf{j}) = [\mathbf{i^m}]^{\kappa_j^m} \, [\mathbf{i^t}]^{(1-\kappa_j^m)}$$

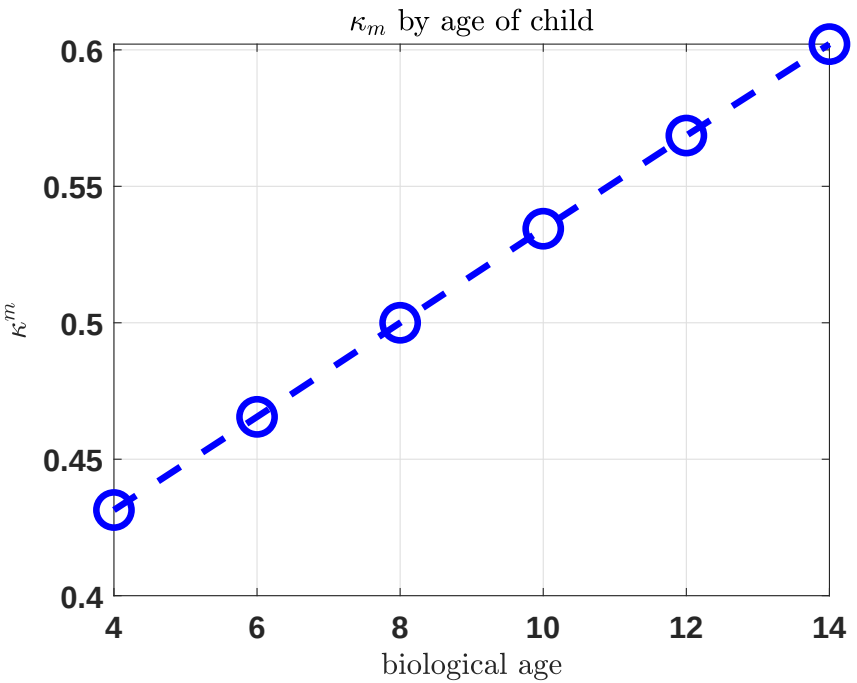
Elasticities taken from the literature:

- $\sigma^h = 1$ (Cunha et al. 2010)
- $\sigma^s = 2.43$ (Kotera/Seshadri 2017)
- $\sigma^m = 1$ (Lee/Seshadri 2019)

Calibrated Age-Dependent Weights κ_j^h, κ_j^m and κ_j^g



(a) Human Capital vs. Investment



(b) Money vs. Time

- Weight on schooling: $\kappa_j^s = 0.676$ for age 6-14: (Kotera/Seshadri 2017)
- For children aged 4 calibrated: $\kappa_0^s = 0.56$
- Targets for age-dependent weights κ_j^h on h and κ_j^m on private i^m: Age dependent time and money inputs by parents (PSID-CDS)

Labor Productivity depends on Human Capital and Education: Complementarity

- Human capital h and education e map into labor productivity γ:

$$\ln\left(\gamma(e,h)\right) = \rho_0(e) + \hat{\rho}_1(e) \cdot \ln\left(\frac{h}{\bar{h}}\right)$$

- $\hat{\rho}_1(e)$ estimated on NLSY79 data (Abbott et al. 2019):

Education Level	Ability Gradient
less than high school	0.351
high school	0.564
college	0.793

- Gradient on h increasing in e: Complementarity

first stage parameters, second stage parameters

Thought Experiment

The Covid-19 Shock

- Covid-19 crisis is an education crisis: temporary decline in schooling input i^g that differs by
  - school type $s \in \{pu, pr\}$
  - age j of child
  - income of parent
- Shock is unexpected, but perfect foresight afterwards (MIT shock)
- Trace out effect on children higher education decisions, PDV of earnings, welfare and public finances
- Counterfactual policy intervention: extend schooling in next two summers.

Main Results

Aggregate Outcomes and Age Heterogeneity

	baseline	Change for Children of Biological Age					
		average	4	6	8	10	12	14
		change in %p						
frac $e = no$	12.16%	**1.55**	1.10	2.22	1.77	1.79	1.38	1.06
frac $e = hs$	54.60%	0.36	0.24	-0.23	0.22	0.54	0.67	0.69
frac $e = co$	33.24%	**-1.91**	-1.34	-1.99	-1.99	-2.33	-2.05	-1.76
		change in %						
av HK	1.00	-2.77	-2.12	-3.19	-2.86	-3.26	-2.81	-2.38
PDV gross y	\$845,149	**-1.73**	-1.32	-1.97	-1.79	-2.05	-1.77	-1.50
PDV net y	\$695,548	-1.39	-1.05	-1.59	-1.44	-1.64	-1.41	-1.19
child CEV	-	**-0.99**	-0.77	-1.14	-1.02	-1.17	-1.01	-0.86

- +13% high school dropouts, -6% college graduates
- -2.77% reduction in average human capital
- Decline of **-1.73%** in earnings, **-0.99%** in welfare
- Larger losses for children in secondary school

Heterogeneity: Public vs. Private Schools

Table: Present Discounted Value of Gross Lifetime Earnings

	baseline	%-Change, Child Age at Covid-19 Shock				
		average	6	8	10	12	14
public	821,404	**-1.77**	-2.01	-1.79	-2.09	-1.82	-1.54
private	1,034,791	**-1.49**	-1.72	-1.78	-1.75	-1.48	-1.24

Table: Welfare (CEV)

	average	6	8	10	12	14
public	**-1.04%**	-1.19%	-1.05%	-1.22%	-1.06%	-0.90%
private	**-0.64%**	-0.75%	-0.71%	-0.73%	-0.64%	-0.55%

- Larger earnings and welfare losses for children going to public school

Heterogeneity: Income-Rich vs. Income-Poor Parents

Table: Welfare (CEV): Bottom, Top Income Quartile, Same School Closures

	average	6	8	10	12	14
bottom	**-1.30%**	-1.49%	-1.31%	-1.51%	-1.30%	-1.10%
top	**-0.53%**	-0.59%	-0.54%	-0.63%	-0.57%	-0.52%

Table: Welfare (CEV): Bottom, Top Income Quartile, Diff. School Closures

	average	6	8	10	12	14
bottom	**-1.11%**	-1.29%	-1.13%	-1.27%	-1.10%	-0.93%
top	**-0.57%**	-0.61%	-0.57%	-0.69%	-0.63%	-0.58%

- Welfare losses larger for children from poorer parents, but...
- Difference ameliorated by 1/3 by difference in length of school closures between income-rich and income-poor counties

National Schooling Expansion

- Expansion of school for 3 months starting from 2022 (e.g., 6 weeks in the summer of 2022 and 2023). Cost of $\$1,396$ per student.

Table: NPV of Schooling Intervention (Net of Cost)

	Abs Change for Children of Biological Age					
	average	6	8	10	12	14
NPV (in $)	**1,018**	1,347	1,170	948	726	428

Table: Welfare Effects (CEV) of Schooling Intervention

	average	6	8	10	12	14
CEV	**0.21%**	0.26%	0.22%	0.19%	0.16%	0.14%

- Reform generates welfare gains and pays for itself: NPV for government approximately zero.

Effects of Covid, School Extensions, on Tax Revenues

Table: Change of Present Discounted Value of Tax Revenues [in %]

Revenue source	All	Lab. Inc.	Cap. Inc.	Cons.
	-2.44	-7.10	0.23	-0.95

Table: Change of Present Discounted Value of Tax Revenues: Covid Shock and Post-Covid Schooling Expansion [in %]

Revenue source	All	Lab. Inc.	Cap. Inc.	Cons.
	-1.94	-5.72	0.22	-0.75

Who Should Get Extra Schooling?

Table: NET Child CEV

	Avg.
Bottom Quartile	0.28%
Top Quartile	0.09%

Table: NPV Government (in $)

	Avg.
Bottom Quartile	$ -147
Top Quartile	$74

- Most welfare gains for children from poor families
- Largest boost in tax revenues if applied to high parental income children.

Sensitivity Analysis: Effectiveness of Online Formats

- Assume on-line schooling is 50% as productive as in-person learning
- Mapping into model: reduction in effective length of school closures by ca. 50%, compression across school types
- Aggregates
  - Decline of -0.80% in earnings, -0.46% in welfare
  - Losses convex in size of school closures: cutting schooling losses by 50% reduces earnings welfare losses by more than 50%
- Distribution of losses: same qualitative patterns as before, but differences across groups shrink.

Heterogeneous Effectiveness of Online Formats

	0% Prod, Homog.	0% Prod	50% Prod
bottom	-1.30	-1.11%	-0.51%
top	-0.53	-0.57%	-0.26%

- Difference by income in length of school closures important, but...
- Potential heterogeneity in effectiveness of online formats perhaps even more so.
- Evidence for such heterogeneity: Halloran et al. (2021), Kogan and Lavertu (2021).

Concluding Remarks

- What we have found:
  - Long-run losses from school closures:

    -1.73% gross earnings, -0.99% CEV
  - Substantial Socio-economic gradient in welfare losses
  - Expansion of school in next two summers increases welfare

    (especially of income-poor children) and roughly pays for itself.
- Caution: not a cost-benefit analysis of school closures. It ignores:
  - Potential health benefits from school closures
  - Loss of social contacts in school
  - Psychological stress for parents and children

THANK YOU FOR ATTENDING AND LISTENING