

# 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.

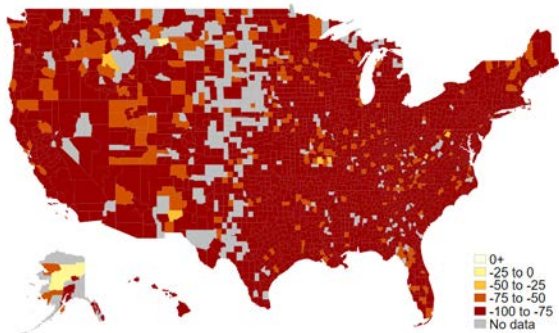


Figure: Avg. change (from 2019) in school visits by county: [March-May 2020](#)

- 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  $\Rightarrow$  Children **starting secondary school** endure largest losses
- ③ Private schools closed less  $\Rightarrow$  Increases inequality since private schools attended by **richer children**
- ④ Public schools in poorer areas closed **less**  $\Rightarrow$  **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

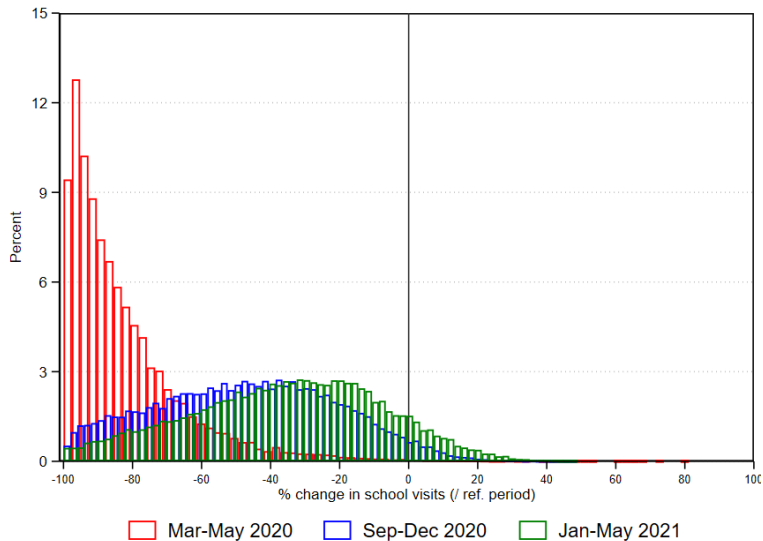
- Weekly visits constructed from cell phone data from [Safegraph](#) to elementary and secondary Schools  $\sim$  125K locations
- Match to National Center for Education Statistics data  $\Rightarrow$  (Universe of the  $\sim$  100K [public schools](#)) and Private School Survey  $\Rightarrow$  (representative 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:

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

- ▶  $v_{j,t}$  = counts of visits to school  $j$  during week  $t$  (norm. by county-level counts of Safegraph devices)
- ▶  $\bar{v}_{j,0}$  = 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

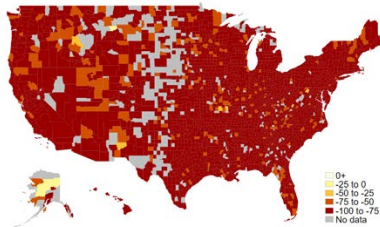


Figure: Avg. change (from 2019) in school visits by county: [March-May 2020](#)

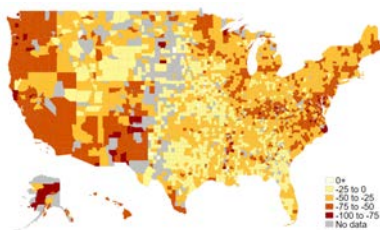


Figure: Avg. change (from 2019) in school visits by county: [Sept.-Dec. 2020](#)

# 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	<b>59.2</b>	<b>62.2</b>	<b>52.3</b>
Public schools	<b>58.5</b>	62.0	51.7
Private schools	<b>65.9</b>	66.2	62.1
	All	Elementary	Secondary
Top 25% inc.	<b>54.5</b>	58.0	46.8
Bot. 25% inc.	<b>63.9</b>	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
$j$	$j \in \{0, 1, \dots, J\}$	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
$\eta$	$\eta \in \{\eta_l, \eta_h\}$	Pers. Prod. Shock
$\varepsilon$	$\varepsilon \in \{\varepsilon_l, \varepsilon_h\}$	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

$\Phi(m,e,a)$

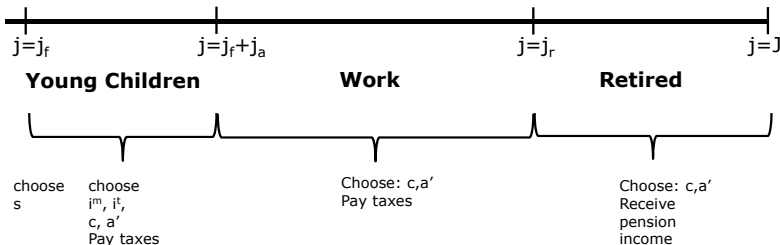
## Children Leave Household

Pay inter-vivos transfers  $b$

## Earnings while Working

wage  $w \in \eta$  until retirement  
working time  $l(m)$  depends on marital status

$\epsilon$  = age and educ. specific wage profile  
 $\eta$  = persistent productivity shock, 2-state Markov  
 $\varepsilon$  = transitory productivity shock



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

## Birth

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

## Higher Education?

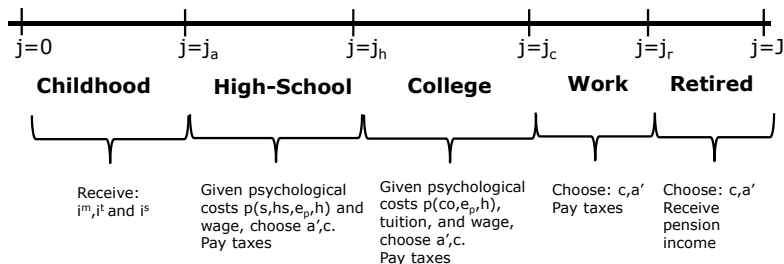
At age  $j_a$  given  $h$   
 i) parents pay inter-vivos transfers  
 ii) children make higher education decision, with psychological costs  $p(s, e, h, e_p)$

Choice:  $e = (\text{no}, \text{hs}, \text{co})?$

## Earnings while Working

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

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



# 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  $h, i^m, i^t, i^s$ .
  - ▶ 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

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

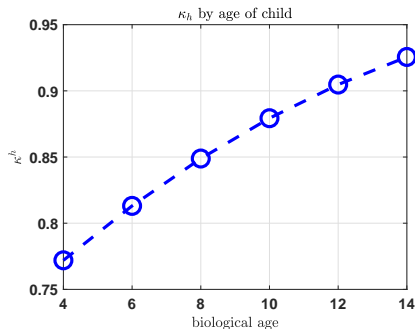
$$\mathbf{i}(\mathbf{i}^s, \mathbf{i}^p; \mathbf{j}) = \bar{A} \left( \kappa_j^s [\mathbf{B}^s \mathbf{i}^s]^{1-\frac{1}{\sigma^s}} + (1 - \kappa_j^s) [\mathbf{i}^p]^{1-\frac{1}{\sigma^s}} \right)^{\frac{1}{1-\frac{1}{\sigma^s}}}$$

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

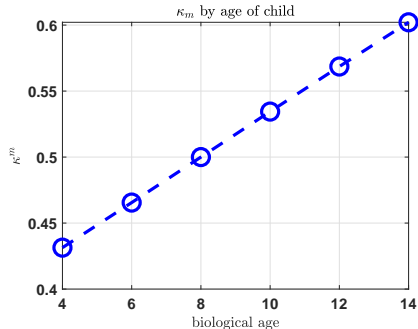
Elasticities taken from the literature:

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

# Calibrated Age-Dependent Weights $\kappa_j^h$ , $\kappa_j^m$ and $\kappa_j^g$



(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  $\kappa_j^h$  on  $h$  and  $\kappa_j^m$  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  $\gamma$ :

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

- $\hat{\rho}_1(e)$  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%	<b>1.55</b>	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%	<b>-1.91</b>	-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	<b>-1.73</b>	-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	-	<b>-0.99</b>	-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	<b>-1.77</b>	-2.01	-1.79	-2.09	-1.82	-1.54
private	1,034,791	<b>-1.49</b>	-1.72	-1.78	-1.75	-1.48	-1.24

Table: Welfare (CEV)

	average	6	8	10	12	14
public	<b>-1.04%</b>	-1.19%	-1.05%	-1.22%	-1.06%	-0.90%
private	<b>-0.64%</b>	-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	<b>-1.30%</b>	-1.49%	-1.31%	-1.51%	-1.30%	-1.10%
top	<b>-0.53%</b>	-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	<b>-1.11%</b>	-1.29%	-1.13%	-1.27%	-1.10%	-0.93%
top	<b>-0.57%</b>	-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 \$)	<b>1,018</b>	1,347	1,170	948	726	428

Table: Welfare Effects (CEV) of Schooling Intervention

	average	6	8	10	12	14
CEV	<b>0.21%</b>	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