The Great Lockdown and the Big Stimulus:

Tracing the Pandemic Possibility Frontier for the U.S.

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Slides at

http://violante.mycpanel.princeton.edu/Slides/PPF_slides.pdf

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What We Do

- Focus: policy response to COVID-19 in the United States
  1. Lockdown: business closure and stay-at-home orders
  2. Stimulus: CARES Act

- Goal: quantify trade-offs
  - Aggregate: lives versus livelihoods
  - Distributional: who bears the economic costs?

- Approach: distributional Pandemic Possibility Frontier (PPF) → PPF
  - Separate economic costs from fatalities
  - Menu of choices, independent of policymakers' preferences
  - Seek policies that shift the frontier inward

How We Do It

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    - Two-way behavioral feedback: between virus & economic activity

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    - Types of market-labor: workplace and remote
    - Occupations: flexibility and sectoral intensity

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- Economic exposure to pandemic correlated with financial vulnerability
- Calibrate model to U.S. economy and examine counterfactuals
    1. Laissez-faire
    2. Lockdown & Lockdown + Fiscal support
    3. 'Smarter' policies: Pigouvian taxation with targeted redistribution

What We Find

1. Economic welfare costs of the pandemic are very heterogeneous
    - Regardless of the policy response
    - Laissez-faire vs lockdown: who bears the cost differs
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4. Taxation-based alternatives to lockdown flatten the PPF
   - Mean trade-off improved, but even more dispersion in outcomes

→ dimensions not considering today

Outline I

Epidemiological Model

- $\mathcal{S}_t$: susceptible
- $\mathcal{I}_t$: infectious
- $\mathcal{R}_t$: recovered
- $\mathcal{E}_t$: exposed = latent virus, not yet infectious
- $\mathcal{C}_t$: critical = in ICU, may ultimately die
- $\mathcal{N}_t$: population = $\mathcal{S}_t + \mathcal{E}_t + \mathcal{I}_t + \mathcal{C}_t + \mathcal{R}_t$

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- Death probability of $\mathcal{C}_t$'s depends on $\mathcal{C}_t \gtrless$ max ICU capacity $\mathcal{C}_{\max}$
- Effective reproduction number: $R_t = \beta_t \frac{1}{\lambda_{\mathcal{I}}} \frac{\mathcal{S}_t}{\mathcal{N}_t}$
- Feedback from economic activity $\rightarrow$ infections

$$\beta_t = \beta_0 \left(\frac{C_{st}}{\bar{C}_s} \right)^{\nu_\beta} \left(\frac{L_{wt}}{\bar{L}_w} \right)^{\nu_\beta}$$

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- Parameterization: $\nu_\beta = 0.8$
  - R_t drops from 2.5 to 0.8 after the lockdown
  - Google Community Indexes of Workplace and Retail drop 50%

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  - Google Community Indexes of Workplace and Retail drop 50%
- Assumption: vaccine arrives after 24 months

→ Google Indexes → Parameters Epi model

Occupations and Sectors

	Flexible	Rigid
C-intensive	Software engineer, architect	Car mechanic, miner
S-intensive	Event planner, social scientist	Waiter, shop assistant

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1. Flexibility: substitutability between remote and workplace hours
   - Total labor supply = $L_w^j + \phi^j L_r^j$

2. Sectoral intensity: share of employment in social vc regular sector, (ξ_s^j, ξ_c^j)

$$Y_i = Z_i N_i^{\alpha_i} K_i^{1-\alpha_i}, \quad N_i = \left[\sum_{j=1}^{J} \left(\xi_i^j \right)^{\frac{1}{\sigma}} \left(N_i^j \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \quad i \in \{s, c\}$$

Occupations and Sectors

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C-intensive	Software engineer, architect	Car mechanic, miner Supermarket clerk
S-intensive	Event planner, social scientist	Waiter, shop assistant Nurse

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3. Essential occupations: exempt from lockdown

Households

- Forward looking and discount at time preference rate (ρ) + death rate
- Period utility: $U[c, s, h] - V[\ell_w, \ell_r, h]$
  - c: regular consumption
  - h: home production
  - ℓ_r: remote hours
  - s: social consumption
  - ℓ_w: workplace hours

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  - ℓ_w: workplace hours
  - ℓ_r: remote hours
- Budget constraint of healthy household working in occupation j

$$\dot{b} = (1-\tau) w^j z \left(\ell_w + \phi^j \ell_r\right) + r^b b + T - c - p_s s - d - \chi(d, a)$$
$$\dot{a} = r^a a + d$$

  - b: liquid assets
  - a: illiquid assets
  - $\phi^j \in [0, 1]$: flexibility of occupation j
  - χ: transaction cost
- Sick households (= $\mathcal{C}$, in ICU): cannot produce, gov't feeds them

Feedback from Virus $\rightarrow$ Economic Activity

- Period utility: $U[c, \upsilon_s(\mathcal{I})s, h] - V[\upsilon_\ell(\mathcal{I})\ell_w, \ell_r, h]$

Feedback from Virus → Economic Activity

- Period utility: $U[c, \upsilon_s(\mathcal{I})s, h] - V[\upsilon_\ell(\mathcal{I})\ell_w, \ell_r, h]$
- Circulation of virus affects (dis)utility from working and consuming s
- Not connected to 'value of life'/fear of death, but to inability to lead a normal life
- Calibration: match drop in activity before executive orders (Google Index)
- Probably a lower bound for behavioral response at the moment

Lockdowns

1. Workplace lockdown: Mandated maximum individual workplace hours

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- Lockdowns affect same behavioral margins as the pandemic

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- Lockdowns reduce infections because reduce $\beta_t = \beta(C_{st}, L_{wt})$
- Lockdowns affect same behavioral margins as the pandemic
- Calibration: (i) 2 months, (ii) match decline in activity (Google Index)
- Assumption: no future lockdown in case of 2nd wave

Remaining Model Ingredients

Investment Fund

- Illiquid asset = shares of a risk-neutral investment fund
- The fund owns K and makes investment decisions

Fiscal Authority

- Issues liquid debt (B^g), spends (G), taxes and transfers (T)

Monetary Authority

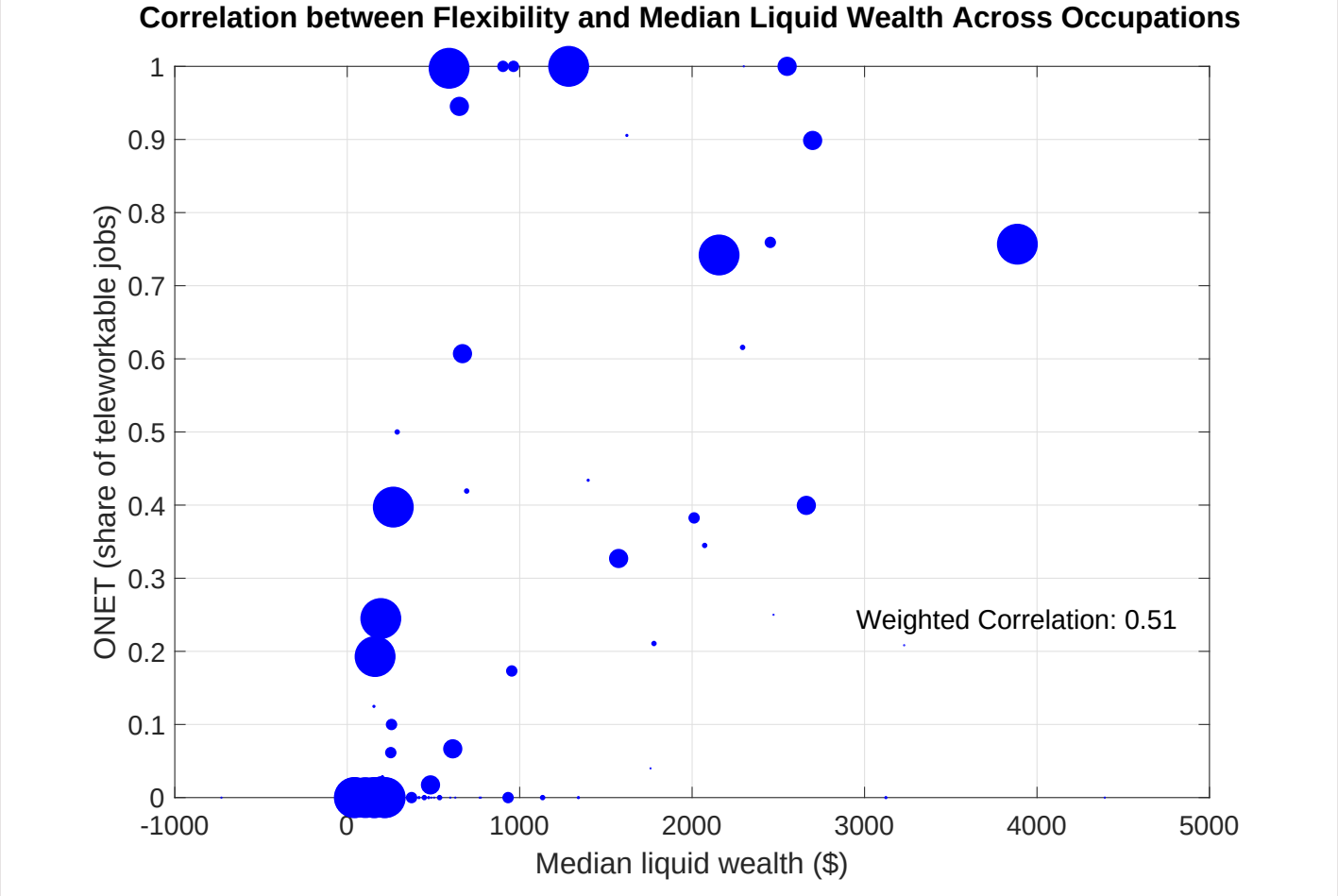
- Central bank absorbs the additional debt needed to finance CARES Act

→ market clearing conditions

→ occupation flexibility details

→ occupation sectoral details

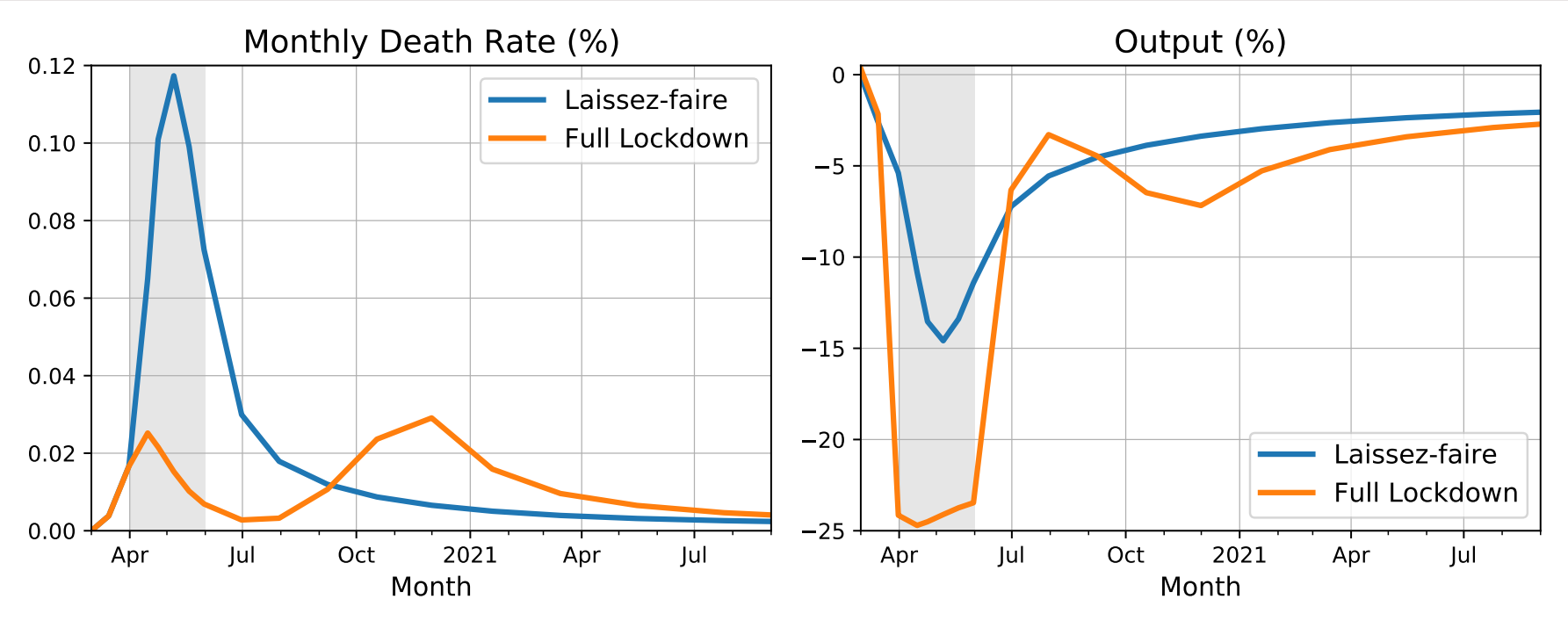
Economic Exposure and Financial Vulnerability



- Model reproduces median liquid wealth holdings by occupation

Outline I

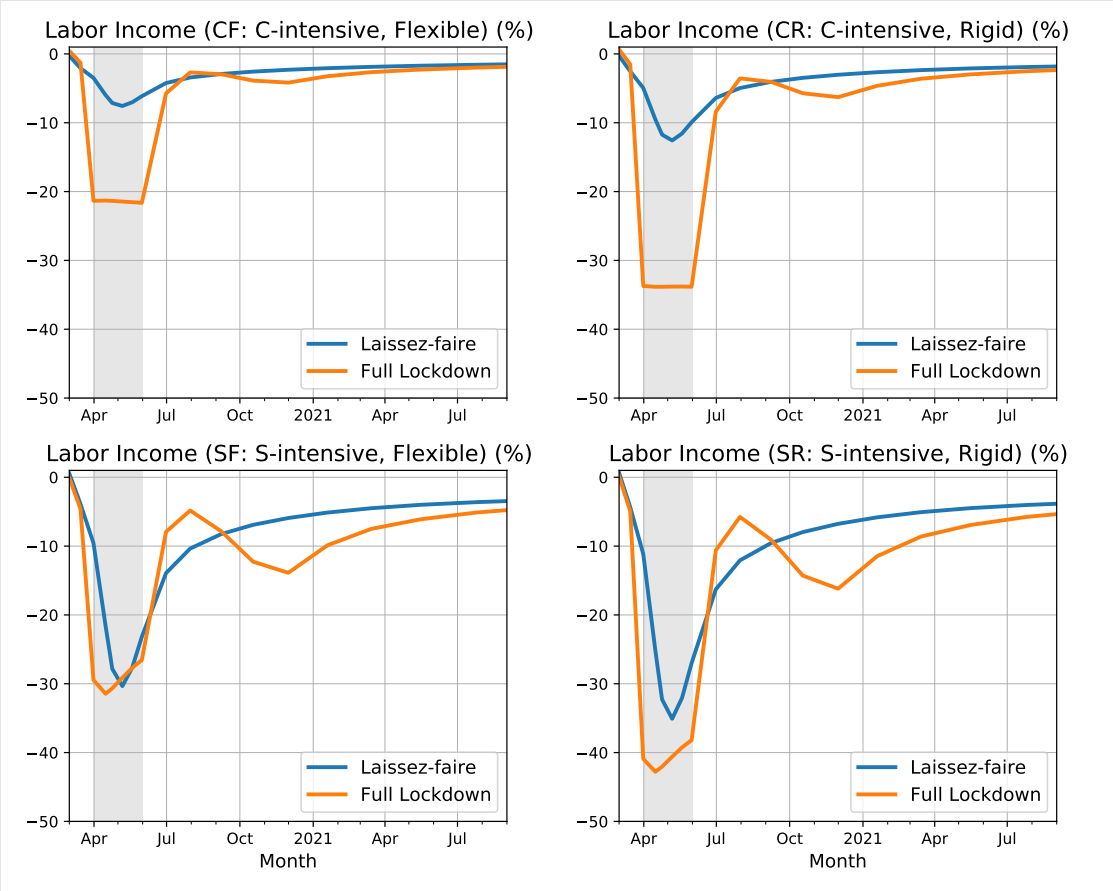
Laissez-faire vs Lockdown: Aggregates



- Lockdown → second wave, but fewer cumulative deaths
- Lockdown → longer, deeper contraction and *W*-shaped recovery

→ laissez-faire dynamics → lockdown dynamics → lockdown decomposition

Laissez-faire vs Lockdown: Occupations



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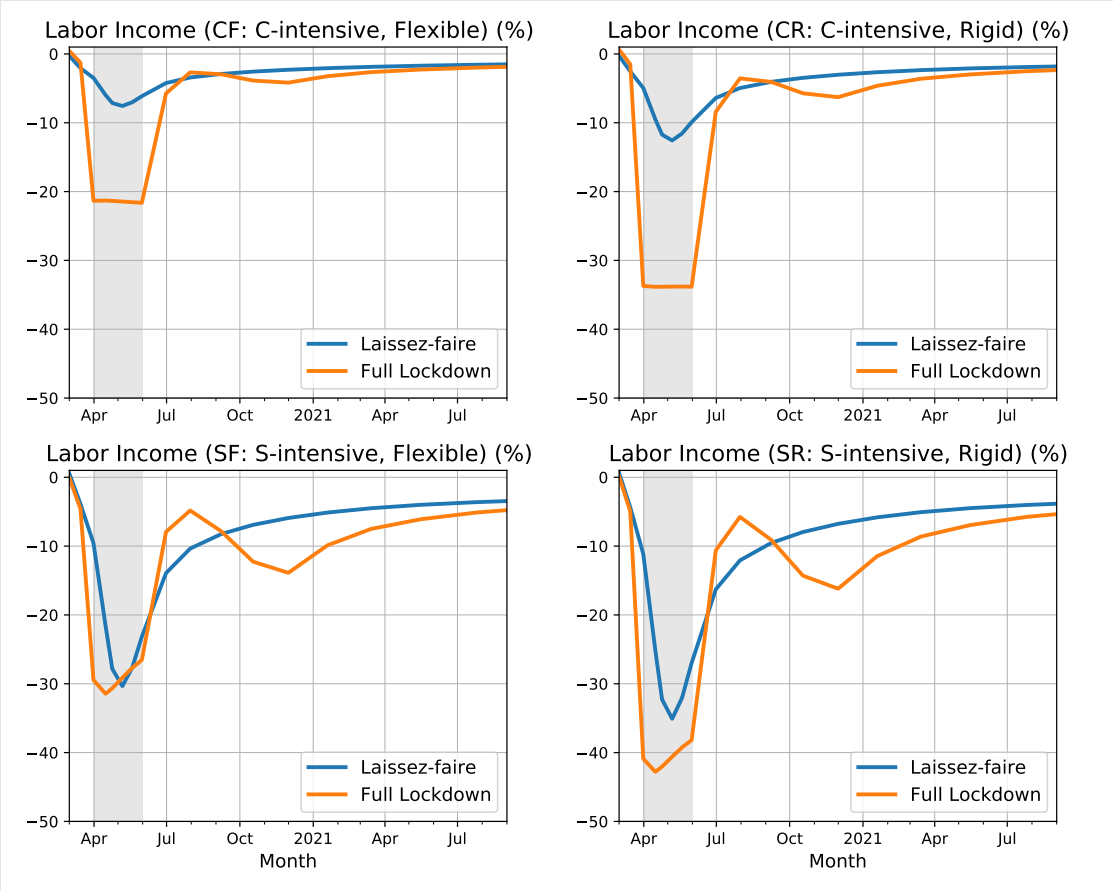
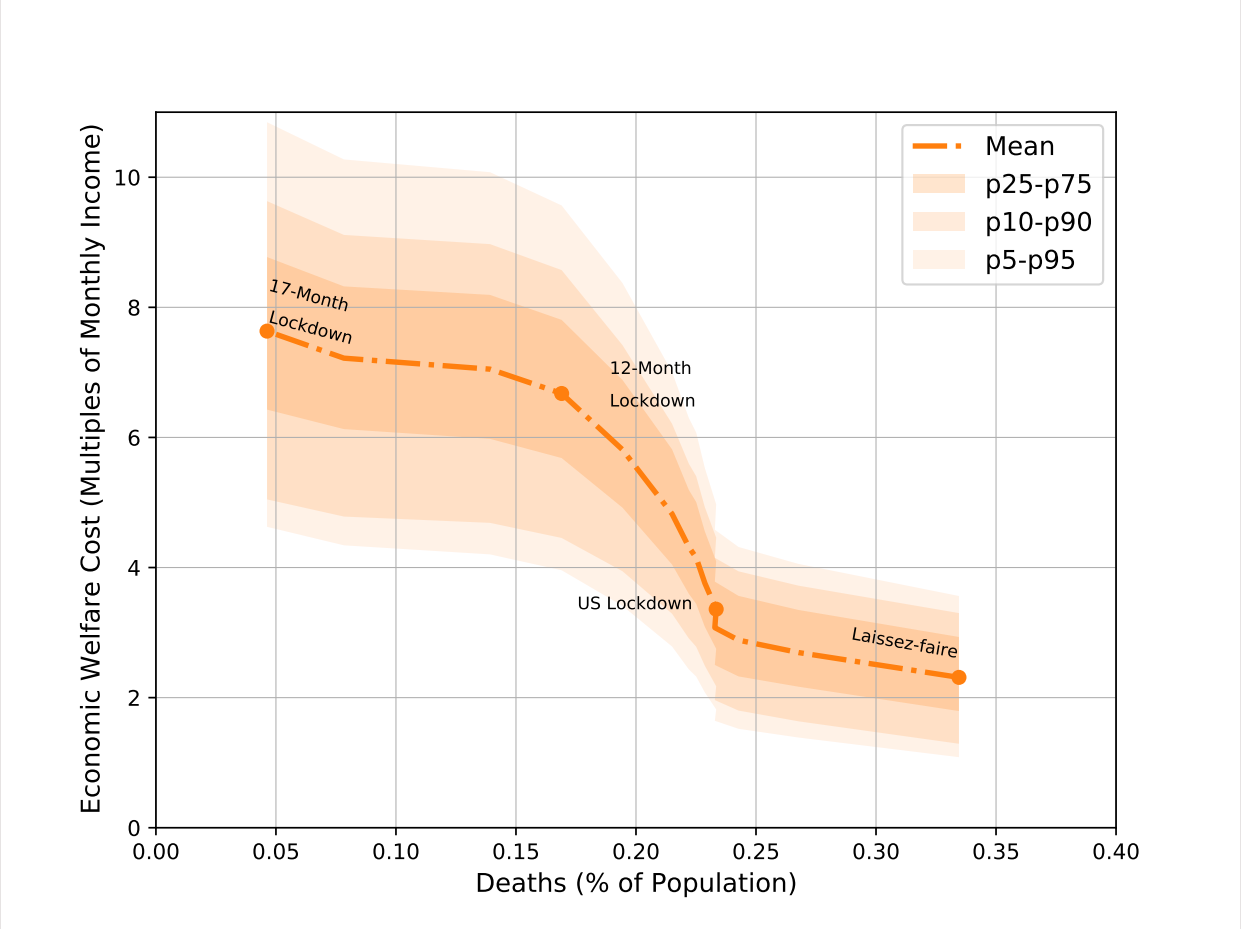
- Lockdown: severe drop in income also for C-intensive occupations

Laissez-faire vs Lockdown: Occupations



- Laissez-faire: large drop in income mainly for S-intensive occupations
- Lockdown: severe drop in income also for C-intensive occupations
- Second wave looks like a laissez-faire recession

Pandemic Possibility Frontier (PPF)



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- Heterogeneity in economic costs exacerbated with longer lockdowns

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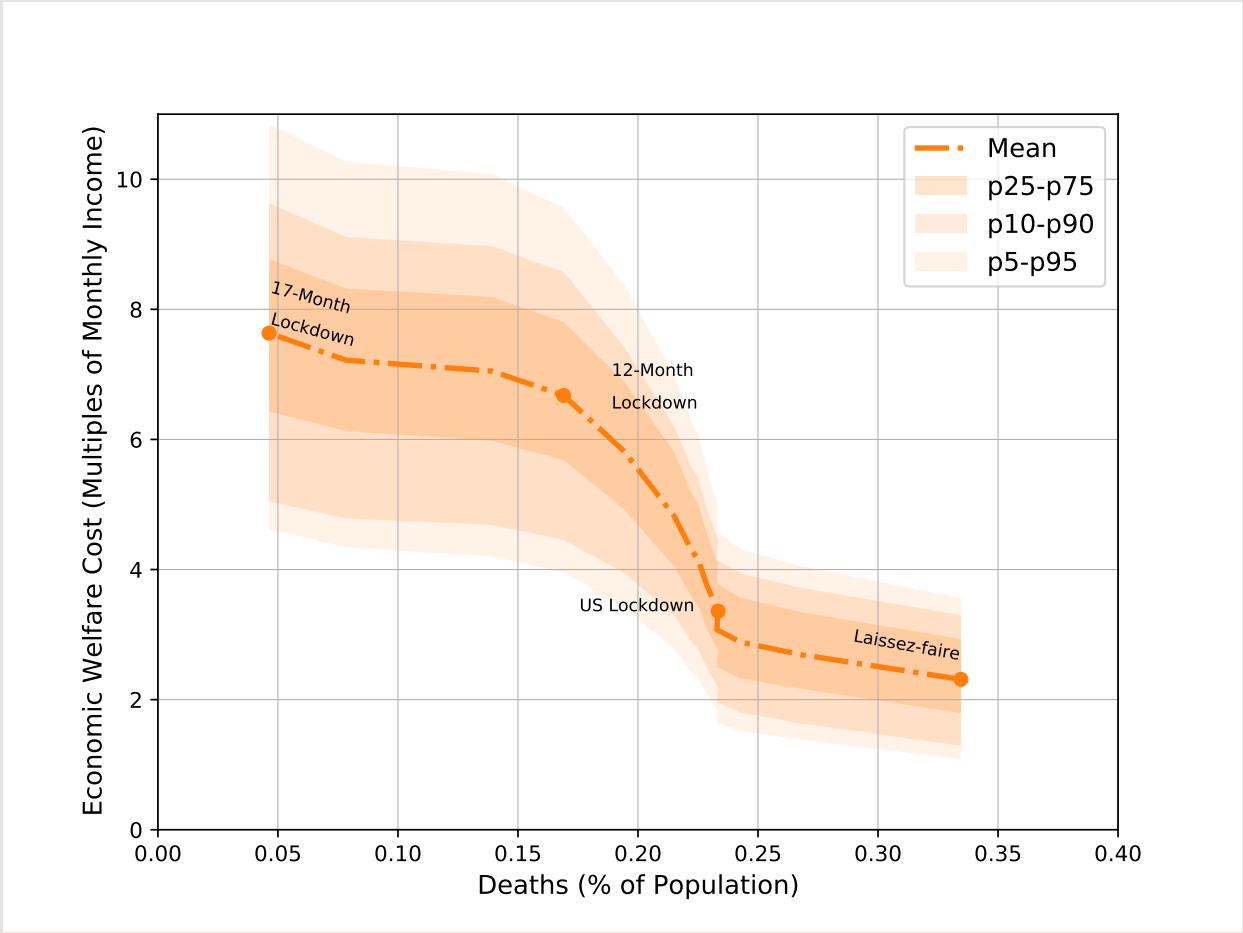
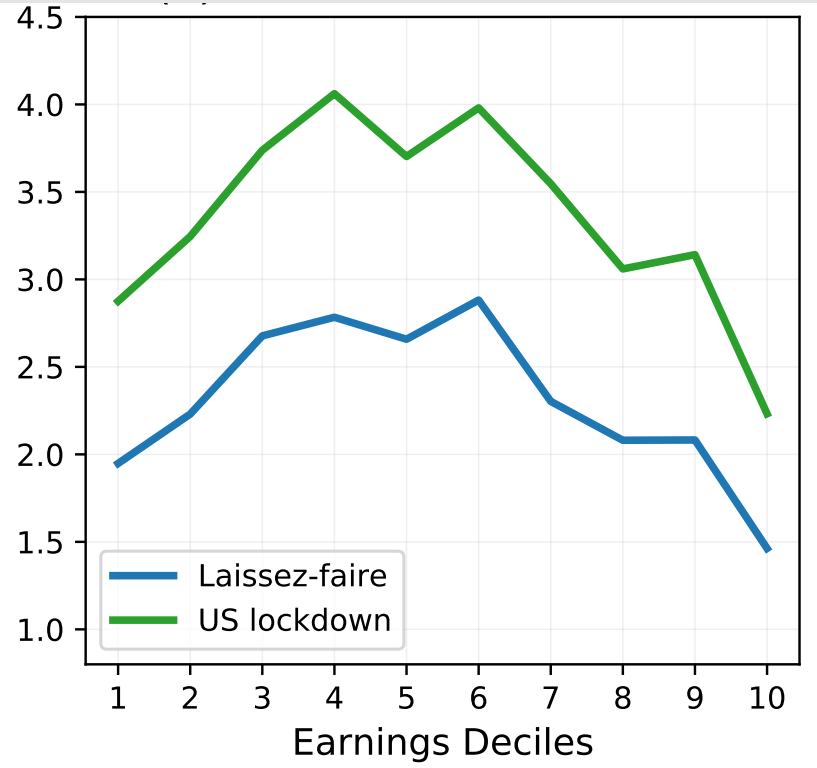


- Large average economic costs and big dispersion
- Heterogeneity in economic costs exacerbated with longer lockdowns
- Very non-linear trade-off: role of ICU constraint and vaccine

→ ppf by occupation

Distribution of Economic Welfare Costs

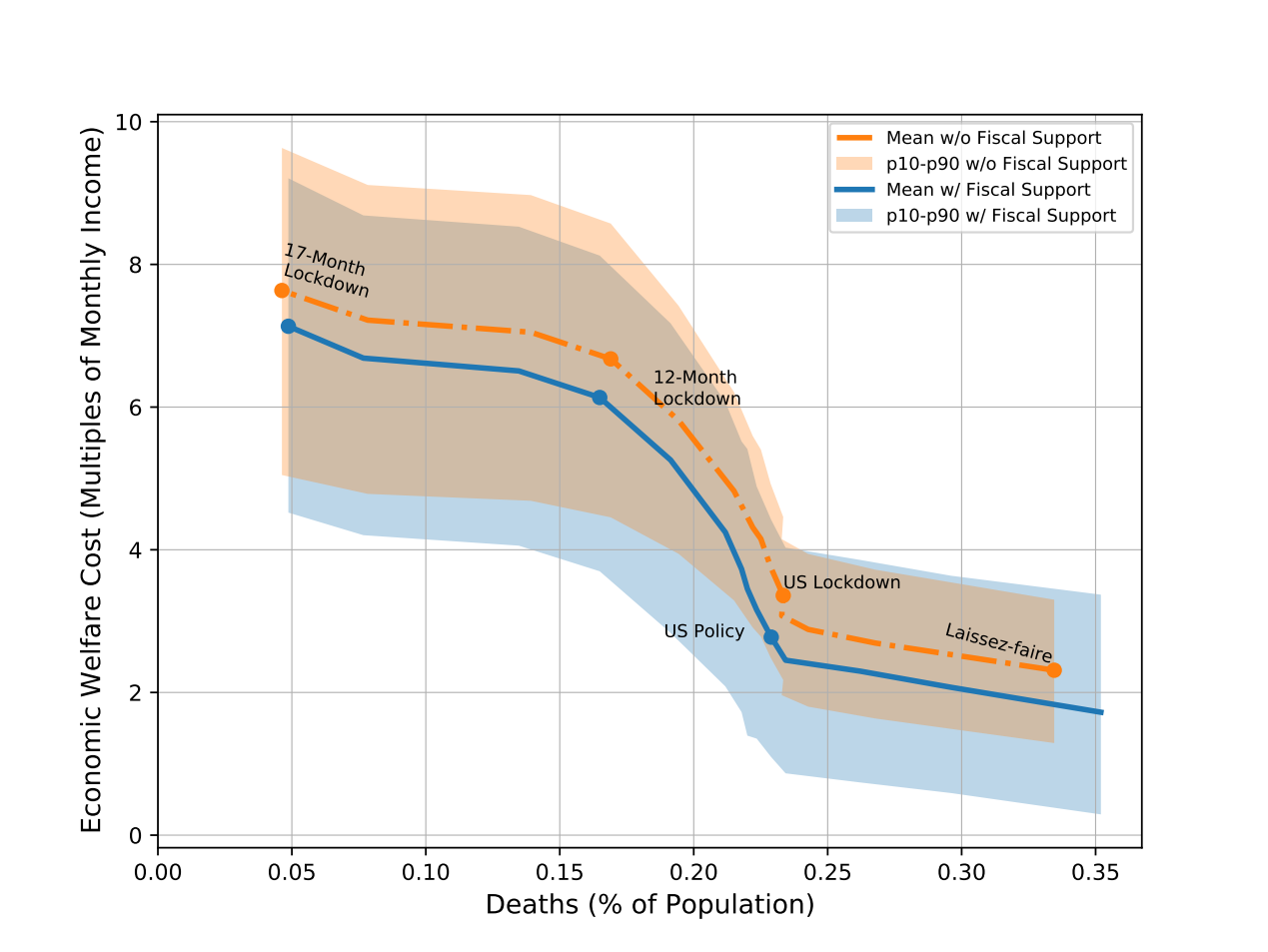


Earnings Decile

- Largest economic costs in middle of distribution
- Transfers (bottom) vs Rigid labor (middle) vs Flexible labor (top)

→ welfare cost distribution

CARES Act Shifts Down the PPF

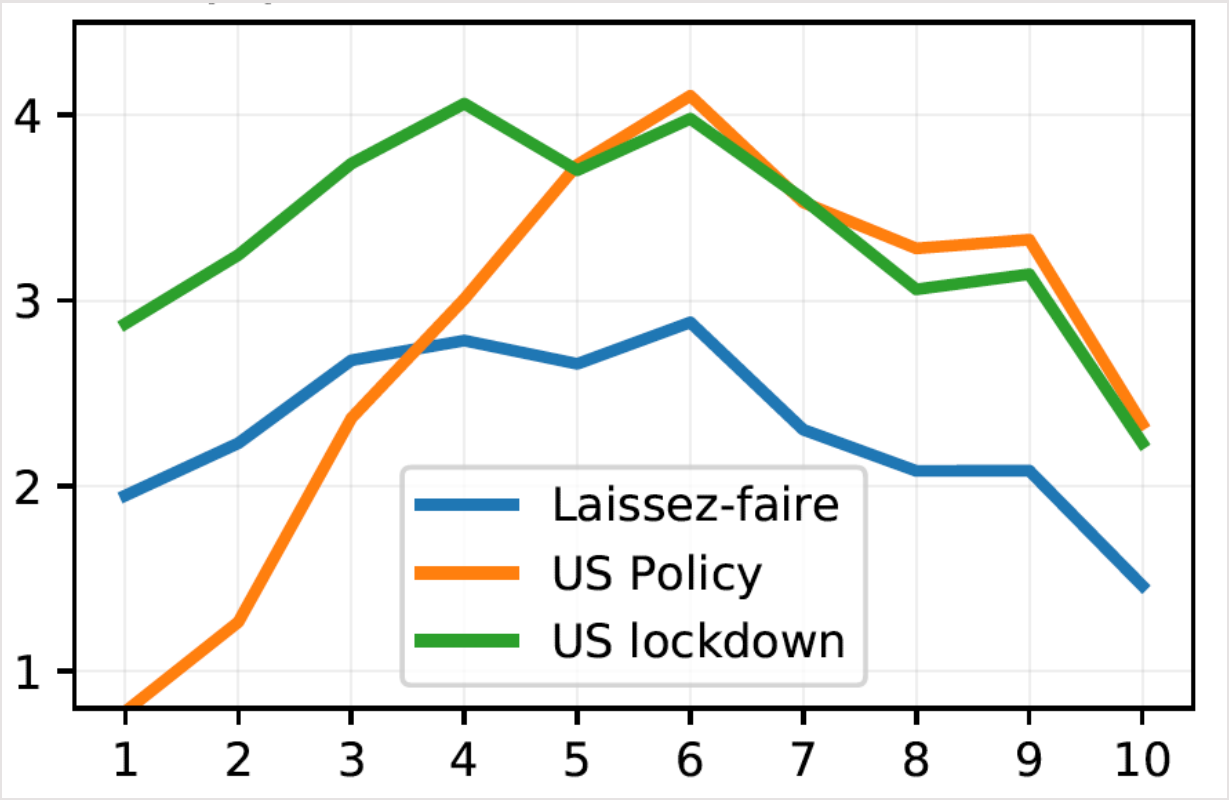


- CARES Act: stimulus checks, pandemic UI, PPP

→ CARES Act details

→ CARES Act dynamics → components of CARES Act → CARES Act by income quartile → components by income quartile

Distribution of Economic Welfare Costs



- Big impact of CARES Act on households below the median
- On economic grounds, bottom 1/3 prefers US policy to laissez-faire

→ welfare cost distribution

Consumption Dynamics

- US Data: biggest y drops, but fastest c recovery at the bottom of the income distribution → US data

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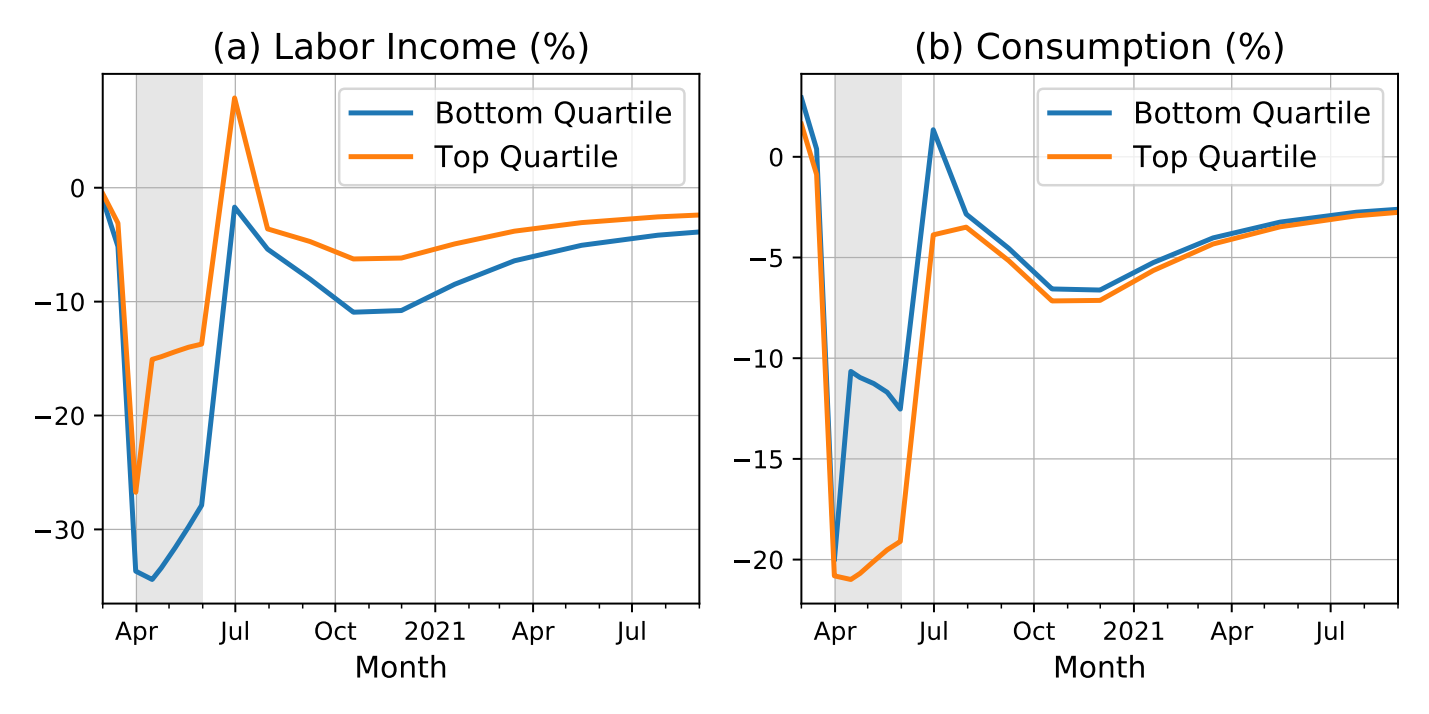
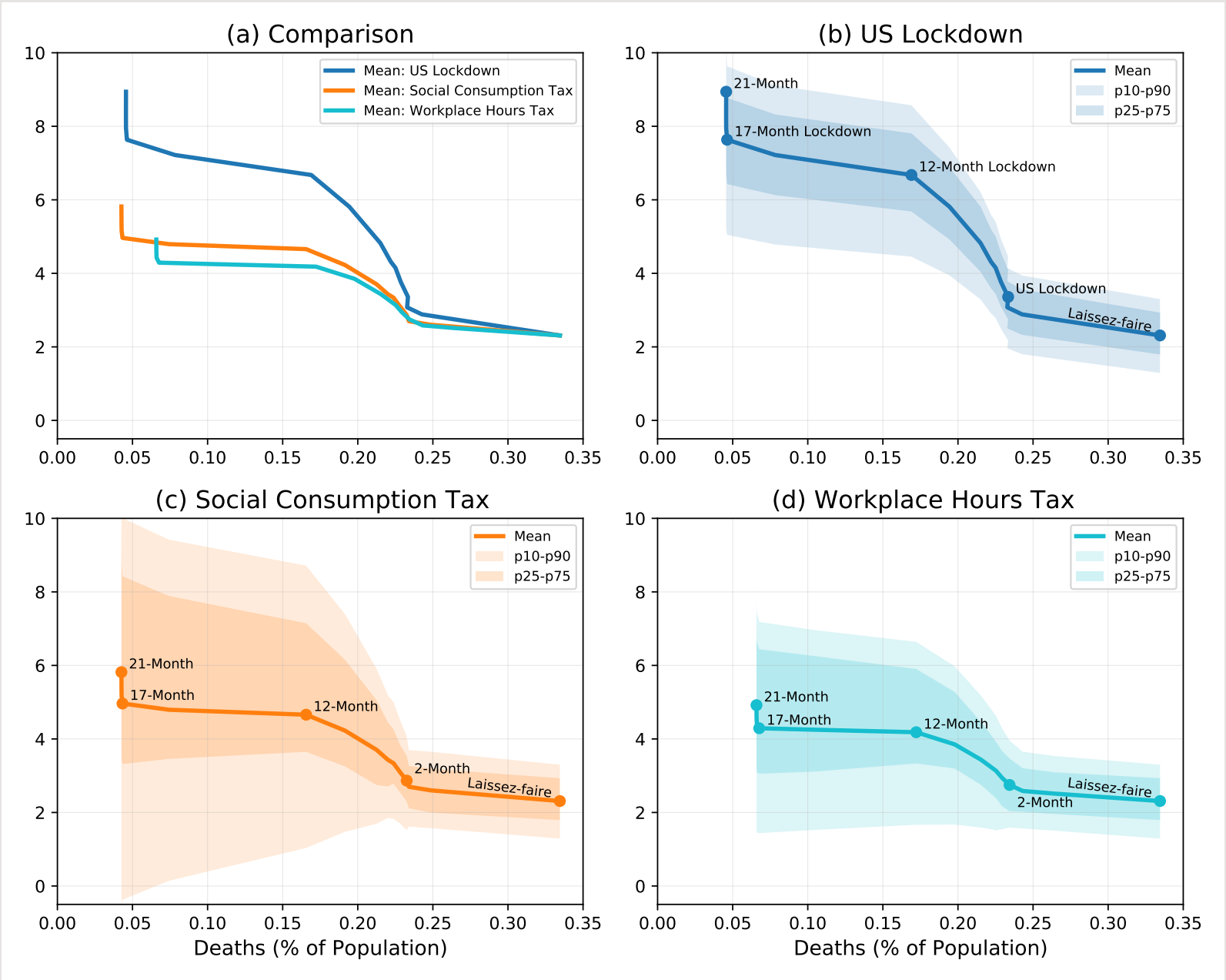


- CARES Act redistributed heavily toward low-income hh with high MPC

→ components of CARES Act by income quartile

Alternative Smarter Polices



Outline I

Messages

1. Economic cost of pandemic: large & diverse, regardless of lockdown

2. Distributional PPF as a tool for quantifying trade-offs:
   - Aggregate: between lives vs livelihoods
   - Distributional: over who bears economic burden

3. Non-linear PPF: reconciles conflicting views on aggregate tradeoff

4. Exposure correlated with vulnerability $\Rightarrow$ scope for fiscal policy

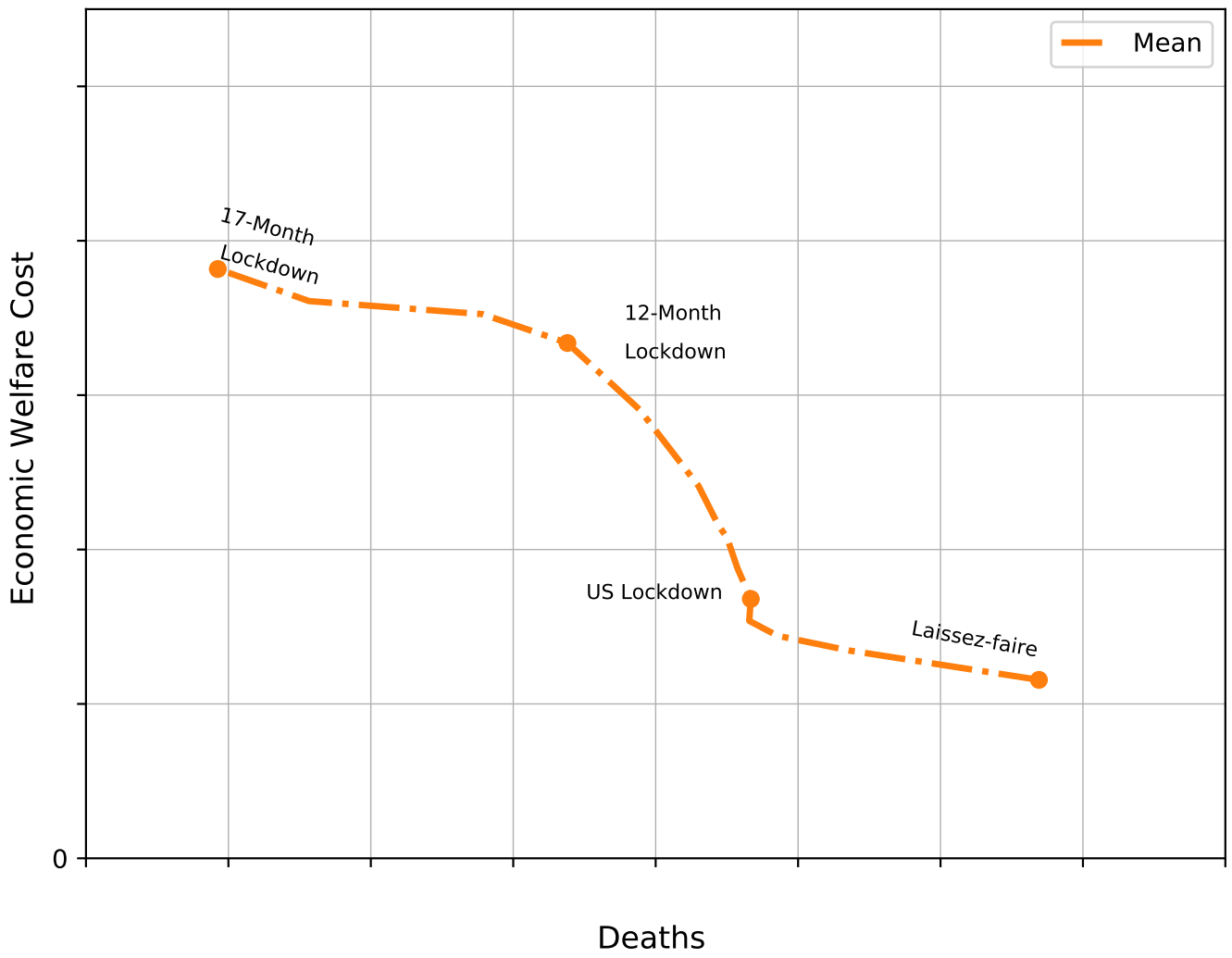
5. US CARES Act:
   - Shifts PPF inward: reduces economic costs w/o increasing deaths
   - Faster recovery of spending for low income households

6. Pigouvian schemes alternative to lockdowns improve aggregate trade-off

Thanks and Stay Safe!

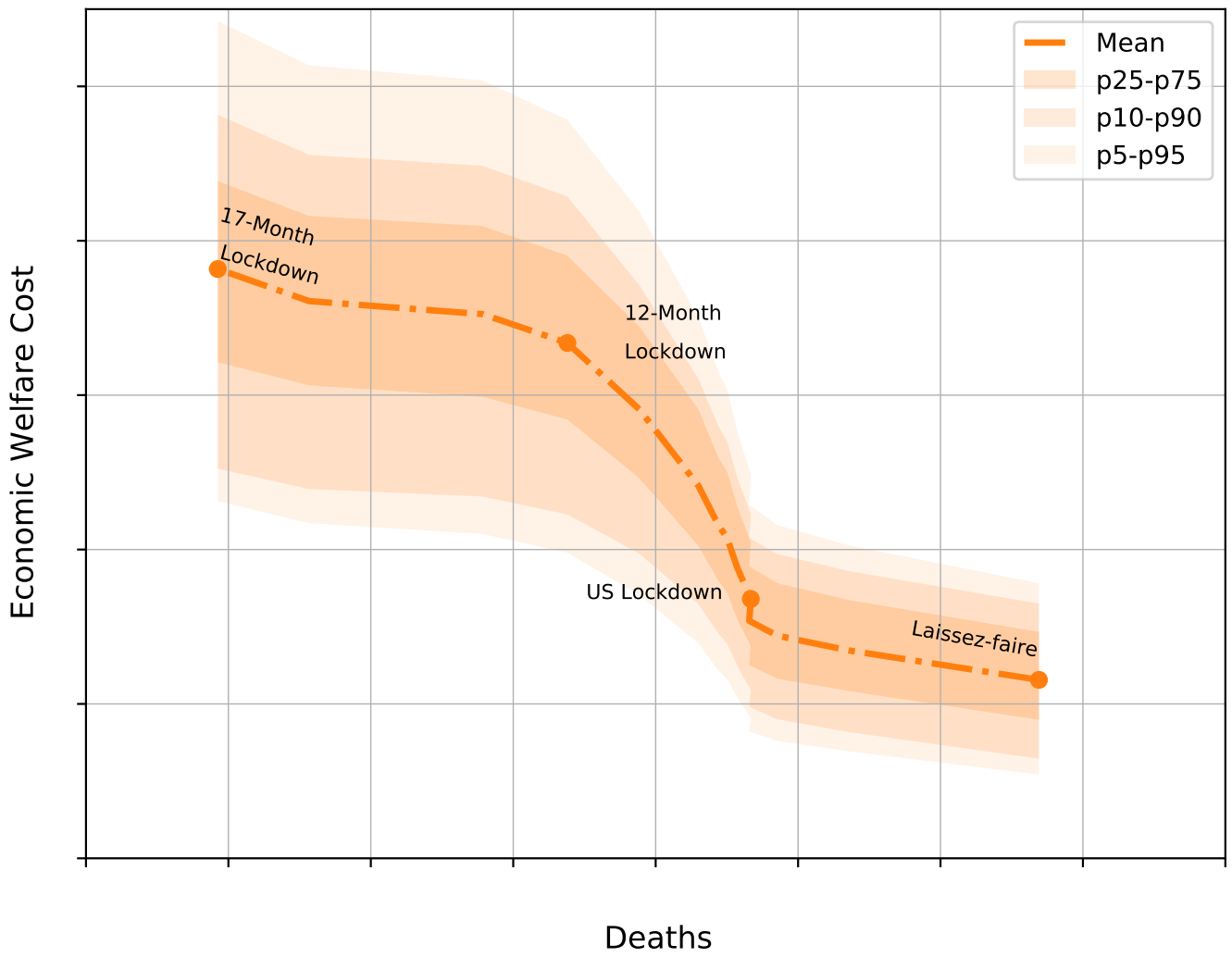
Outline I

Pandemic Possibility Frontier



→ back to intro

Pandemic Possibility Frontier



→ back to intro

Some Dimensions we Abstract From

1. Differential impact of the epidemic across age groups
   (Glover-Heathcote-Krueger-RiosRull, Bairoliya-Imrohoroglu, Acemoglu et al., Brotherhood-Kircher-Santos-Tertilt, ...)

2. Differential impacts of the epidemic across gender
   (Alon-Doepke-Olmstead Rumsey-Tertilt, ...)

3. Impact of the epidemic on deaths from other causes

4. Input-output linkages in production
   (Baqaee-Farhi, ...)

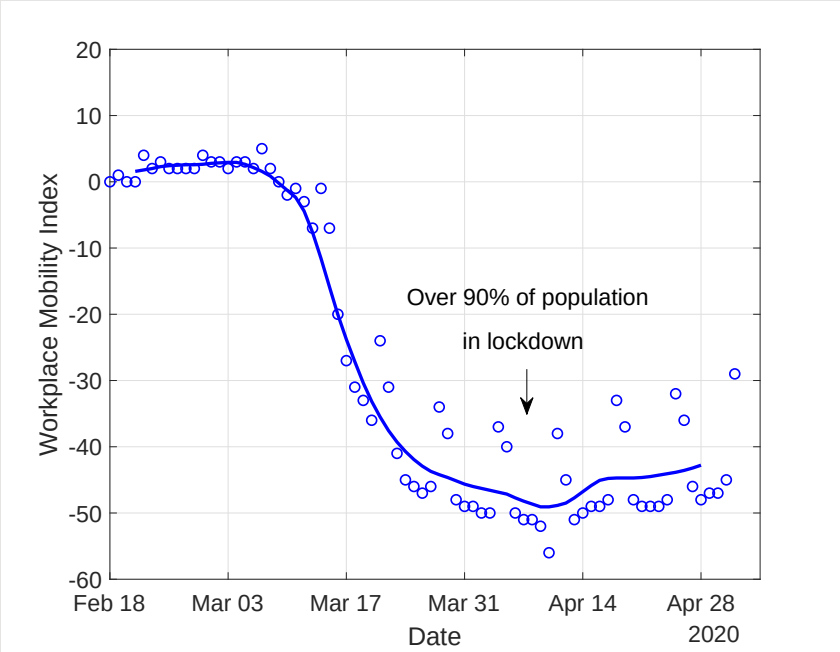
5. Firm balance sheets, liquidity provision to firms
   (Buera-Fattal Jaef-Neumeyer-Shin, Elenev-Landvoigt-VanNieuwerburgh, ...)

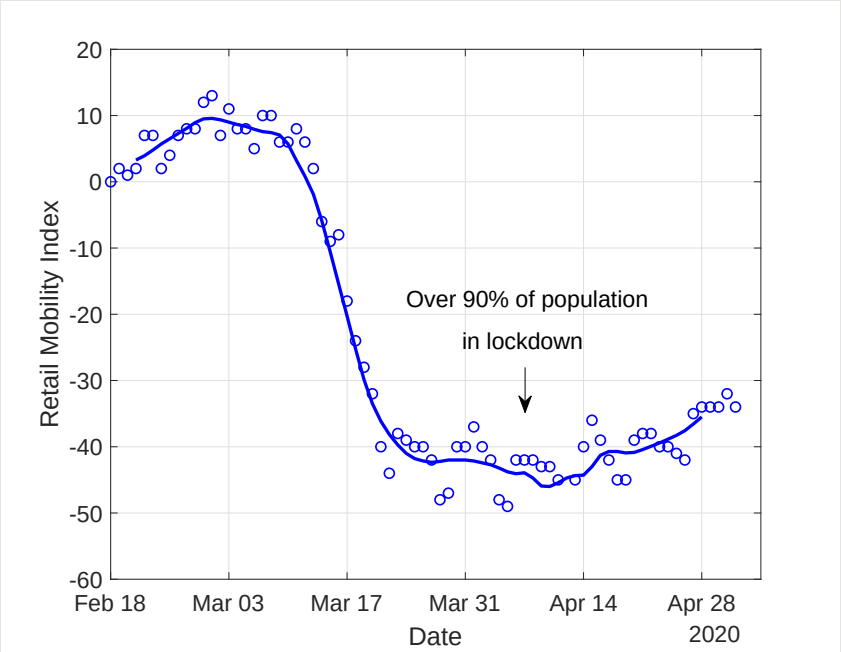
6. Costly destruction of viable employment relationships

7. ...

→ model ingredients

Google COVID-19 Community Mobility Data





→ back to Epi model

Background on Lockdowns in SIR Models

- Some vocabulary:
  1. Basic reproduction number: $R_0 := \beta_0/\lambda_I$
  2. Effective reproduction number: $R_t^e := R_0 \times \mathcal{S}_t/\mathcal{N}_t$
  3. Herd immunity threshold: $\mathcal{S}^*/\mathcal{N} := 1/R_0$ or $\mathcal{R}^*/\mathcal{N} = 1 - \mathcal{S}^*/\mathcal{N} = 1 - 1/R_0$
  4. Final size of disease: $\mathcal{S}_\infty = e^{-R_0(1-\mathcal{S}_\infty)}$

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- Two key features of SIR models:
  1. Infections $\uparrow$ if $R_t^e > 1$ or $\mathcal{S} > \mathcal{S}^*$ and $\downarrow$ otherwise
  2. Epidemic "overshoot": total infections > herd immunity, $\mathcal{S}_\infty > \mathcal{S}^*$

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- Results on lockdowns := $R_0 \downarrow$
  - Even temporary lockdowns reduce total number of infections
  - But total number of infections $\geq$ herd immunity threshold
  - Best lockdowns-only can do is eliminate epidemic "overshoot"
  - If lockdown too short or too tight, get 2nd wave

→ back to Epi model

Market Clearing Conditions

- Regular goods market

$$Y_c = C_c + I + G + \chi$$

- Social goods market

$$Y_s = C_s$$

- Labor market for each occupation

$$N_c^j + N_s^j = \int z(\ell_w^j(\mathfrak{h}, a, b, z) + \phi^j \ell_r^j(\mathfrak{h}, a, b, z))d\mu, \quad j = 1, \ldots, 5$$

- Liquid asset market

$$B^h = B^g$$

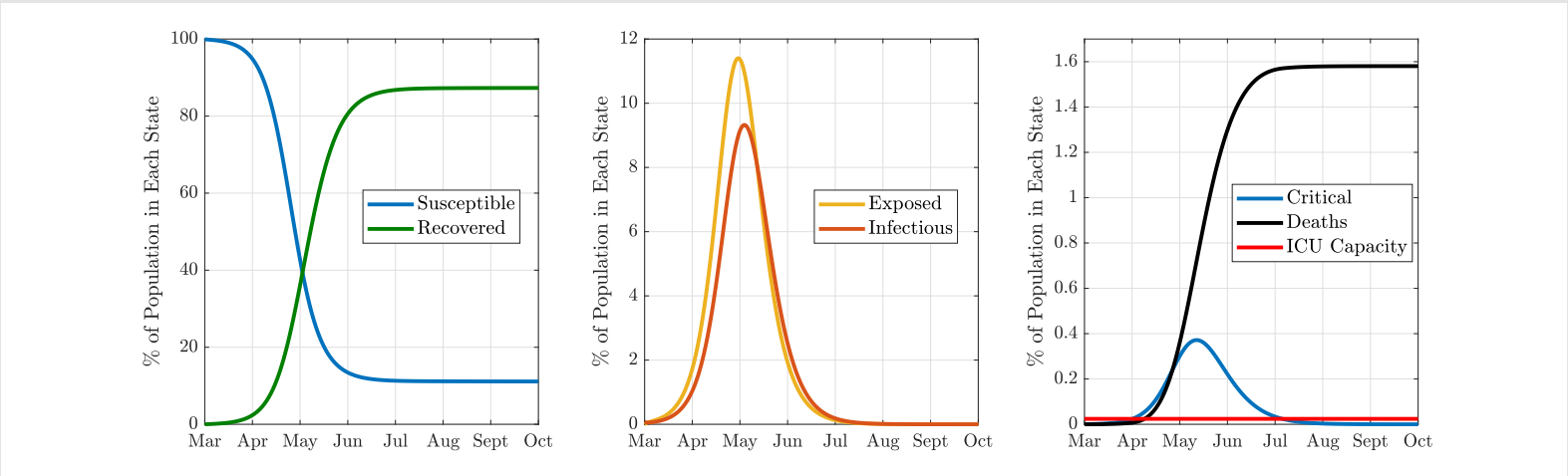
- Illiquid asset market

$$A = V_{\text{fund}}(K, \Theta_c, \Theta_s), \quad K = K_c + K_s$$

→ model ingredients

Epidemiological Parameters

Description	Parameter	Value
Initial basic reproduction number	$R_0^{\text{init}} = \beta_0^{\text{init}}/\lambda_I$	2.5
Final basic reproduction number	$R_0^{\text{end}} = \beta_0^{\text{end}}/\lambda_I$	2
Avg. duration of $\mathcal{I}$nfectious	$T_I \Rightarrow \lambda_I = 1/T_I$	4.3 days
Avg. duration of $\mathcal{E}$xposure (latency)	$T_E \Rightarrow \lambda_E = 1/T_E$	5.0 days
Infection fatality rate	IFR $= \chi\delta_C$	$0.02 \times 0.33 = 0.066$

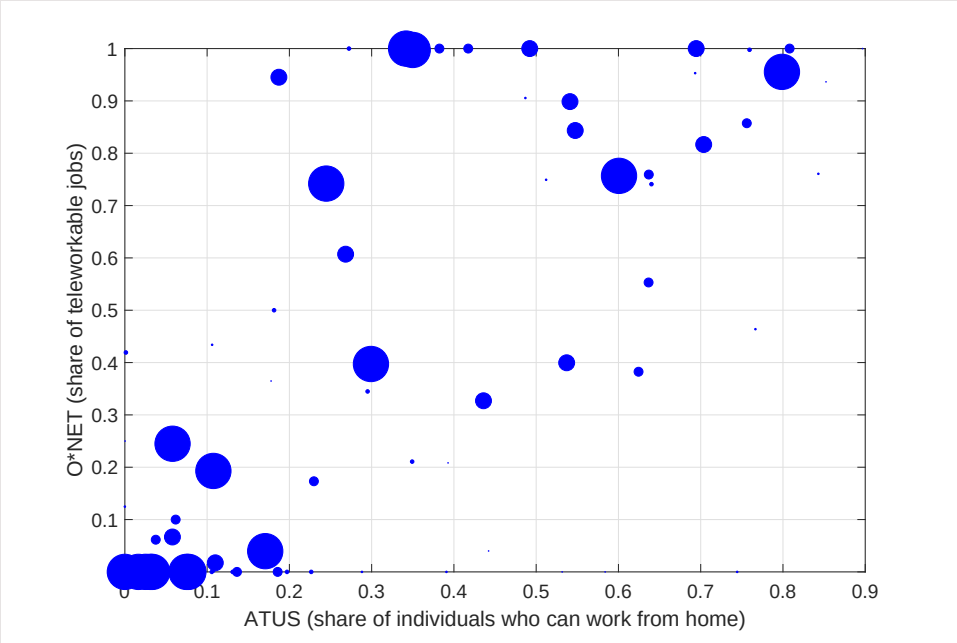


- Time trend in transmissions (masks,...): $\tilde{R}_t = (1-\omega_t)R_0 + \omega_t \bar{R}$, $\bar{R} = 1.5, \omega_t =$ logistic
- Herd immunity threshold: $1 - 1/R_0^{\text{init}} = 60\% \Rightarrow 1 - 1/R_0^{\text{end}} = 50\%$
- Vaccine arrival after 18 months

→ back to Epi model

Occupations: Flexibility

- O*NET: Share of tasks that can be performed at home (Dingel-Neiman)
- ATUS Q: As part of your (main) job, can you work at home?
- Systematic variation across 3-digit SOC occupations



- Two flexibility levels: high flexibility occupation if O*NET share > 0.5.

→ back to model

Occupations: Social vs Regular Intensity

NAICS code	**Sector** C (value added share: 0.74)	**NAICS code**	**Sector** S (value added share: 0.26)
11	Agriculture, forestry, fishing, and hunting	44-45	Retail trade
21	Mining	481-482-483	Air, rail, and water transportation
22	Utilities	485-487-488	Transit and scenic transportation
23	Construction	61	Educational services
31-32-33	Manufacturing	62	Health care and social assistance services
42	Wholesale trade	531-532-533	Real estate, rental and leasing services
484-486	Truck and pipeline transportation	71	Arts, entertainment, and recreation services
491-492	Postal transportation	72	Accommodation and food services
493	Warehousing and storage	81	Other services (excluding P.A.)
51	Information		
52	Finance and insurance		
–	Housing services		
54-55	Professional, technical, and scientific services		
56	Management and administrative services		

→ back to model

Occupations: Exposure vs Vulnerability

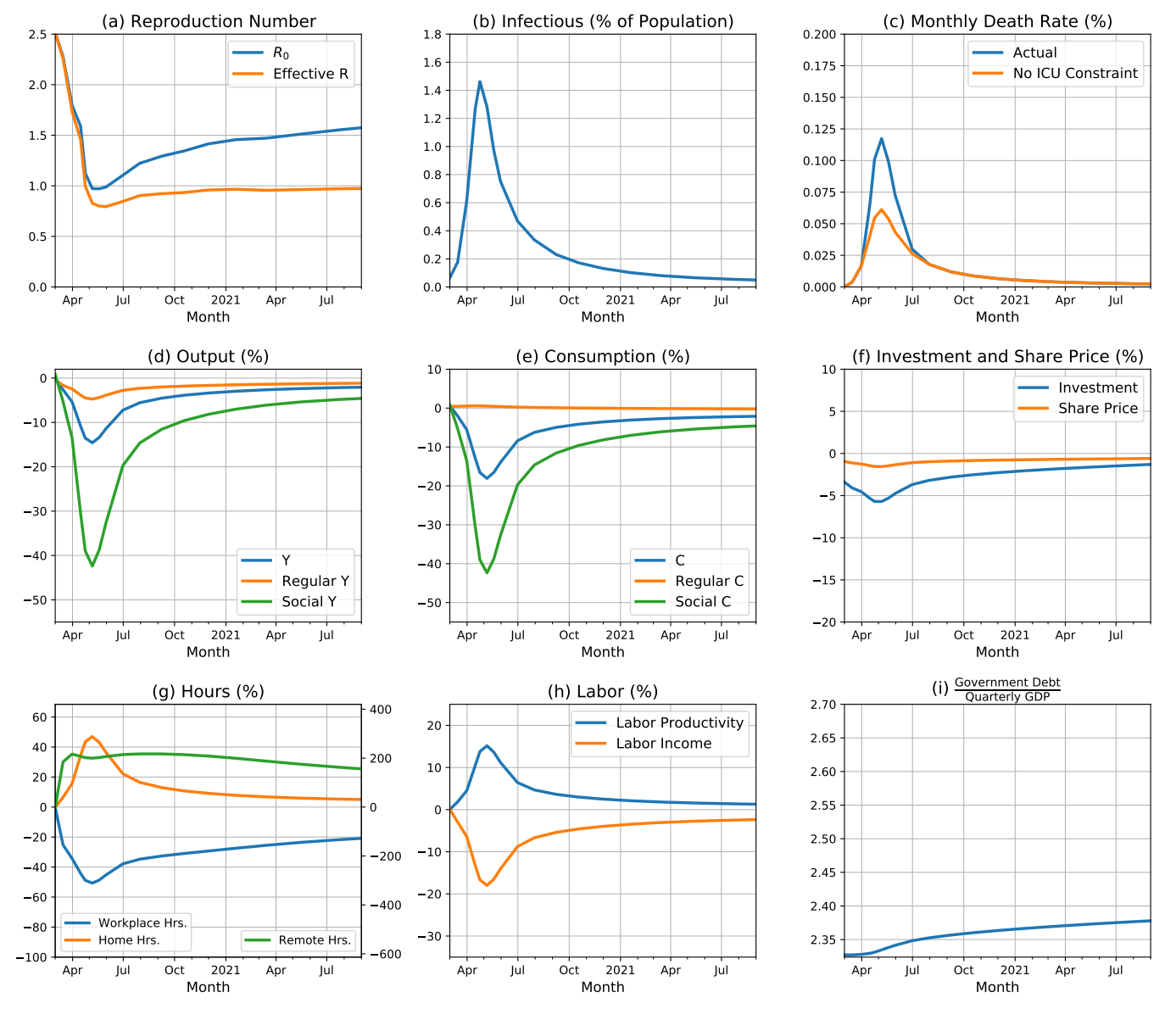
Occupation	ϕ^j	ξ_c^j	ξ_s^j	Empl Share	Earnings	Liq Wealth
Essential	0.1	0.19	0.35	0.31	$\$45K$	$\$1,300$
CF: C-intensive, Flexible	1	0.57	0.12	0.21	$\$79K$	$\$18,400$
SF: S-intensive, Flexible	1	0.03	0.19	0.10	$\$51K$	$\$8,900$
CR: C-intensive, Rigid	0.1	0.19	0.04	0.13	$\$45K$	$\$1,000$
SR: S-intensive, Rigid	0.1	0.04	0.29	0.24	$\$32K$	$\$900$

Source: O*NET, OES, SIPP

- Estimate stochastic processes for household wage dynamics by occupation from PSID
- To match liquid wealth we add occupational-specific wedge on liquid rate

→ back to model

Aggregates Dynamics: Laissez-Faire



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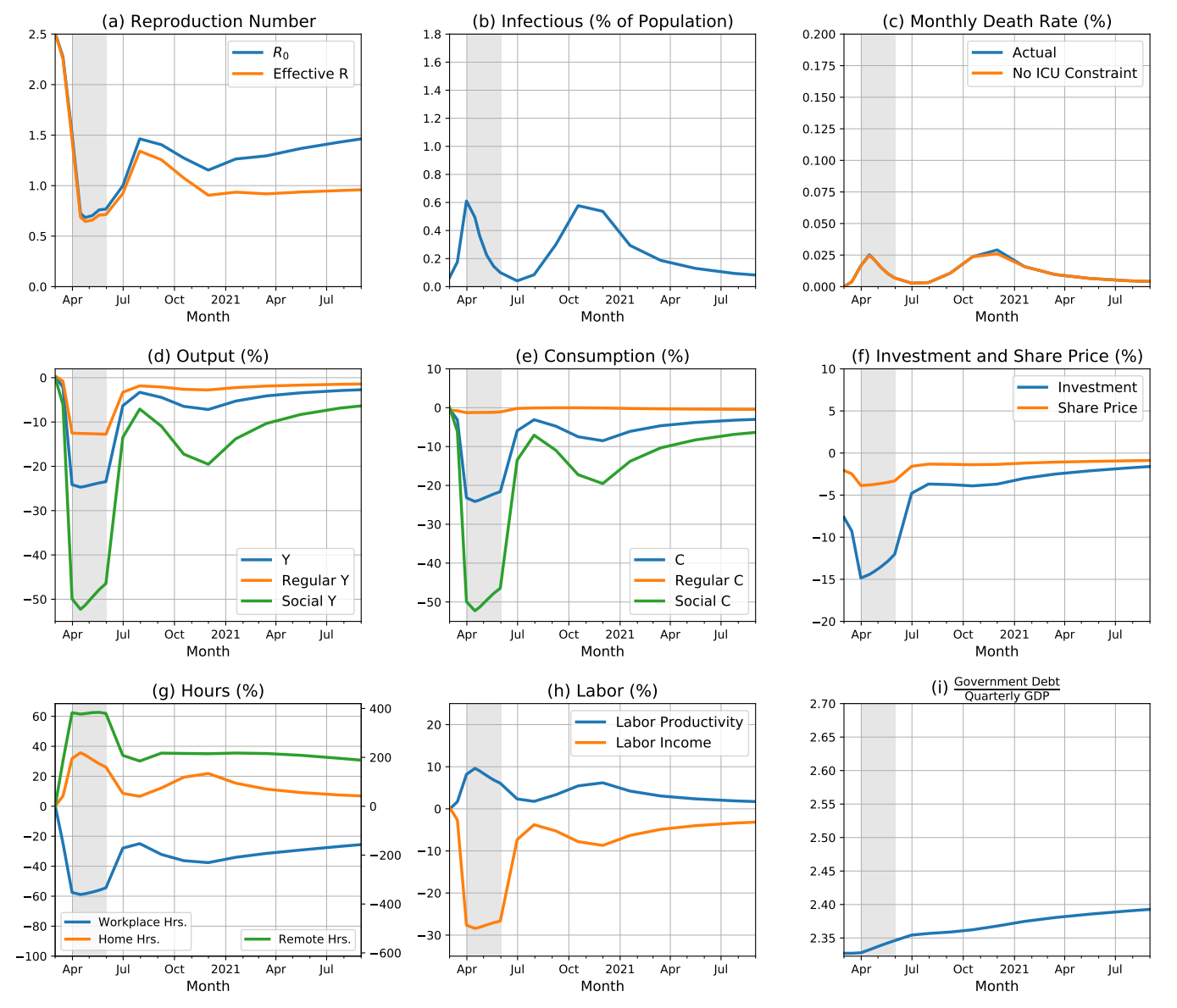
Aggregates Dynamics: Lockdown



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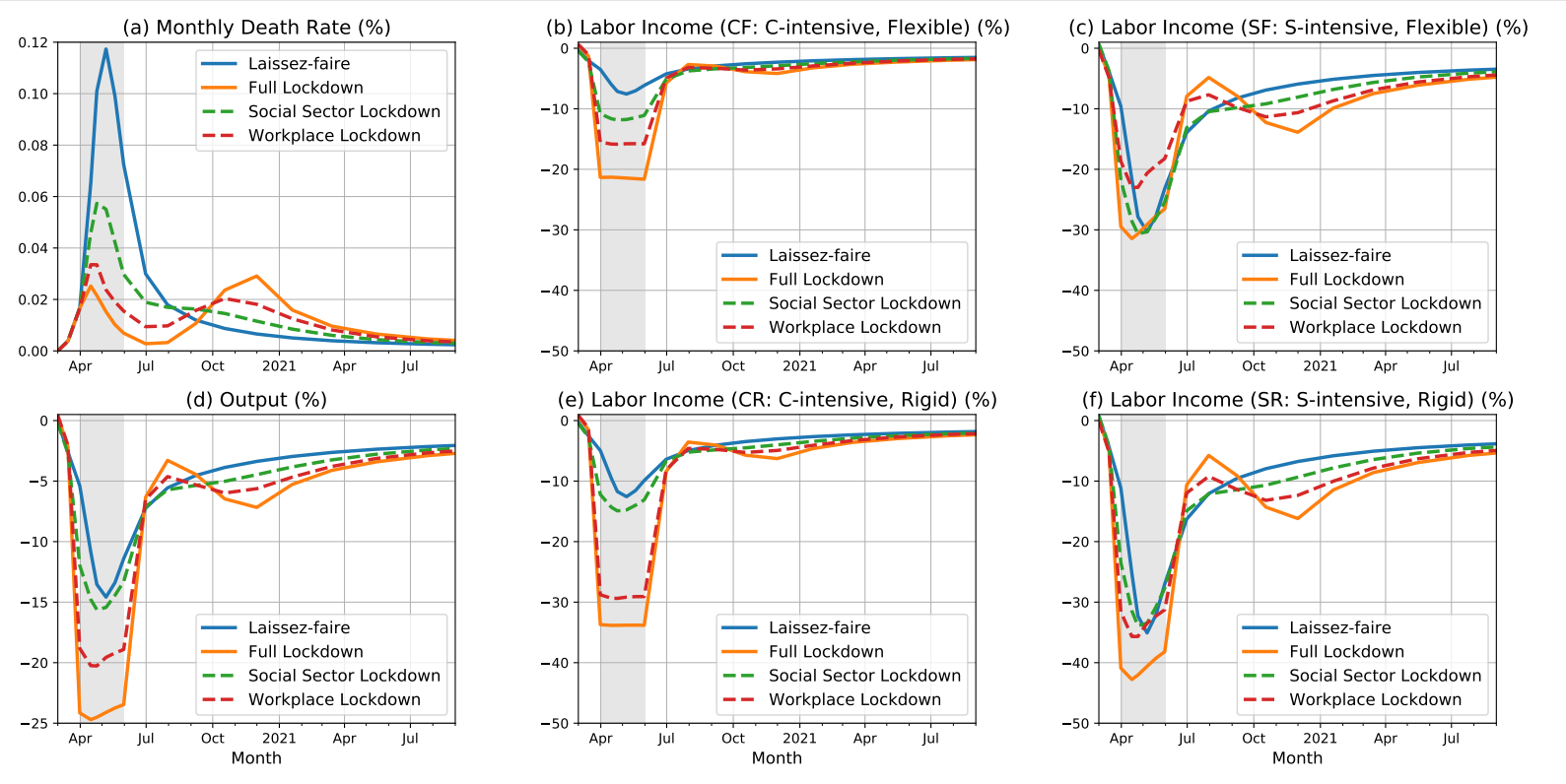
Lockdown Decomposition



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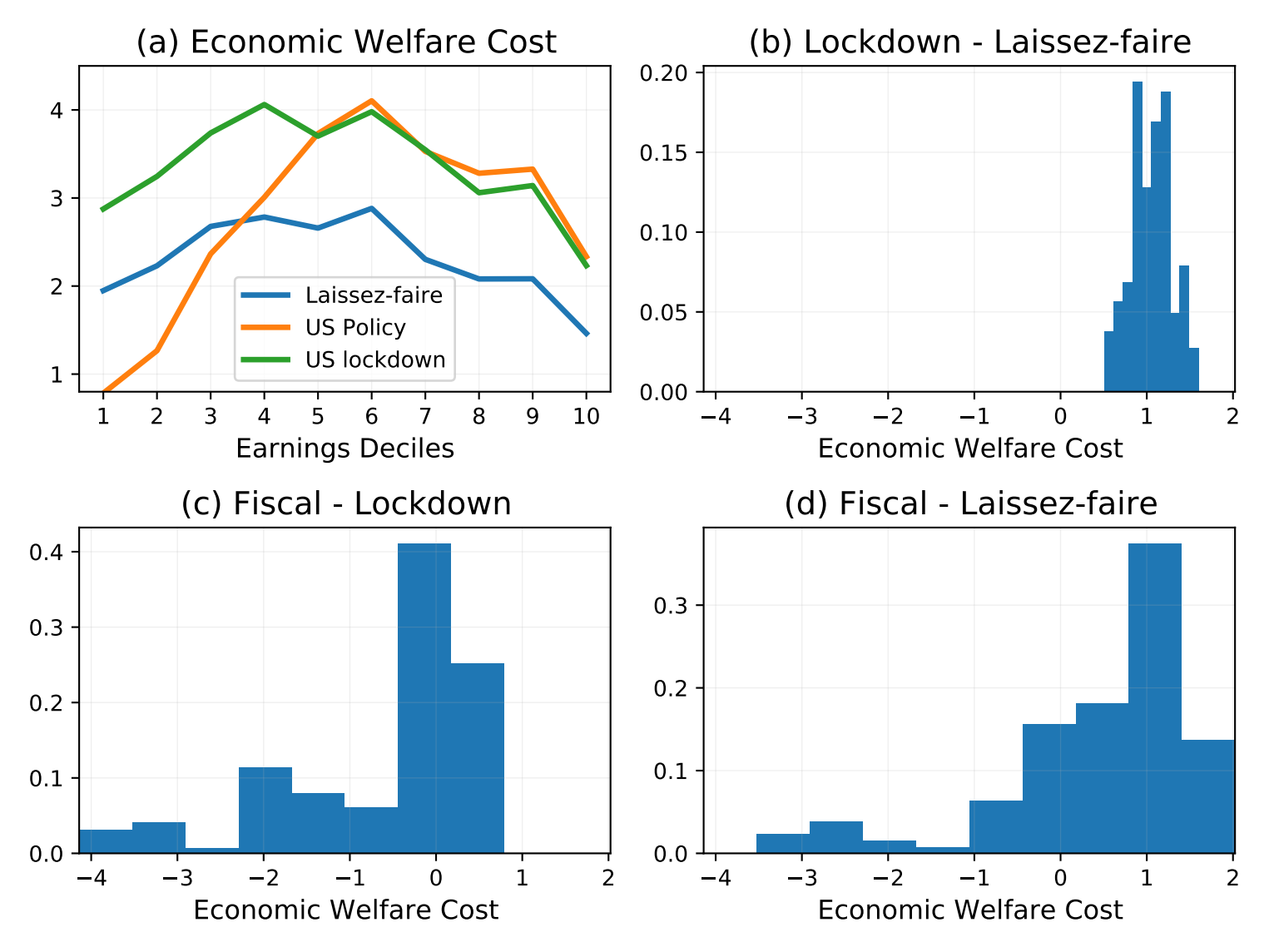
Economic Welfare Cost Distribution



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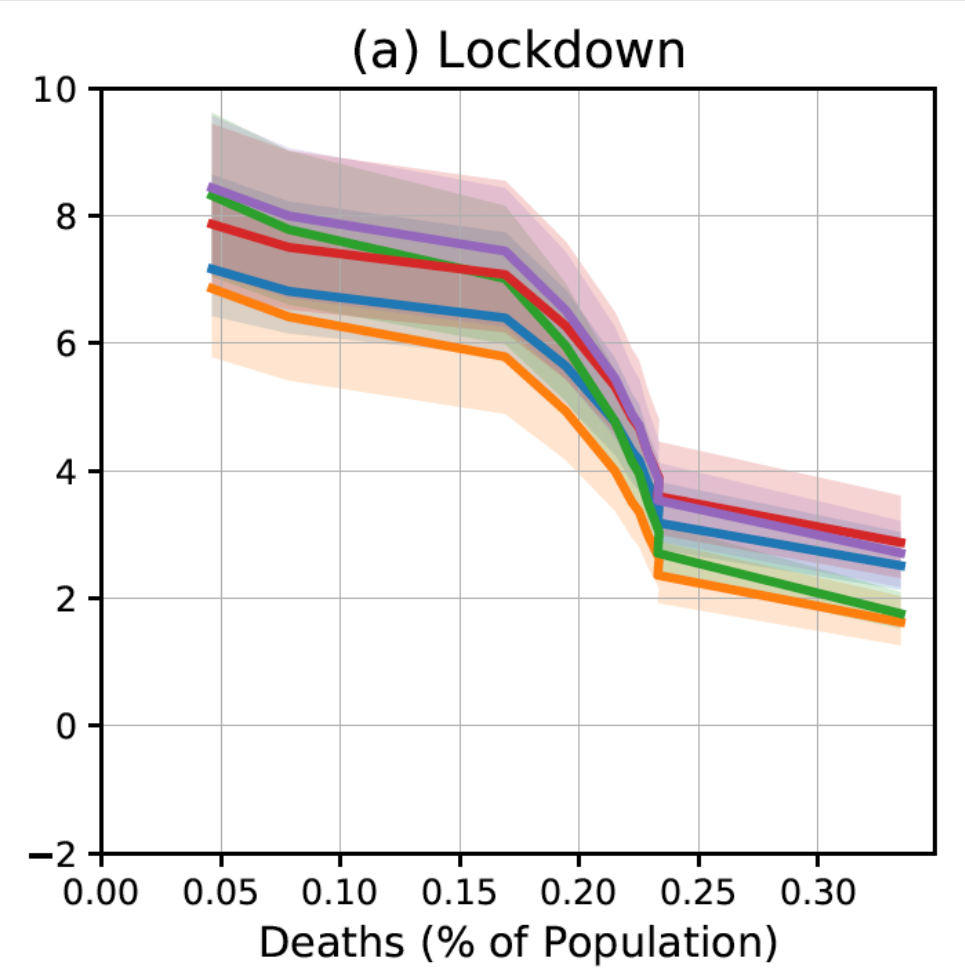
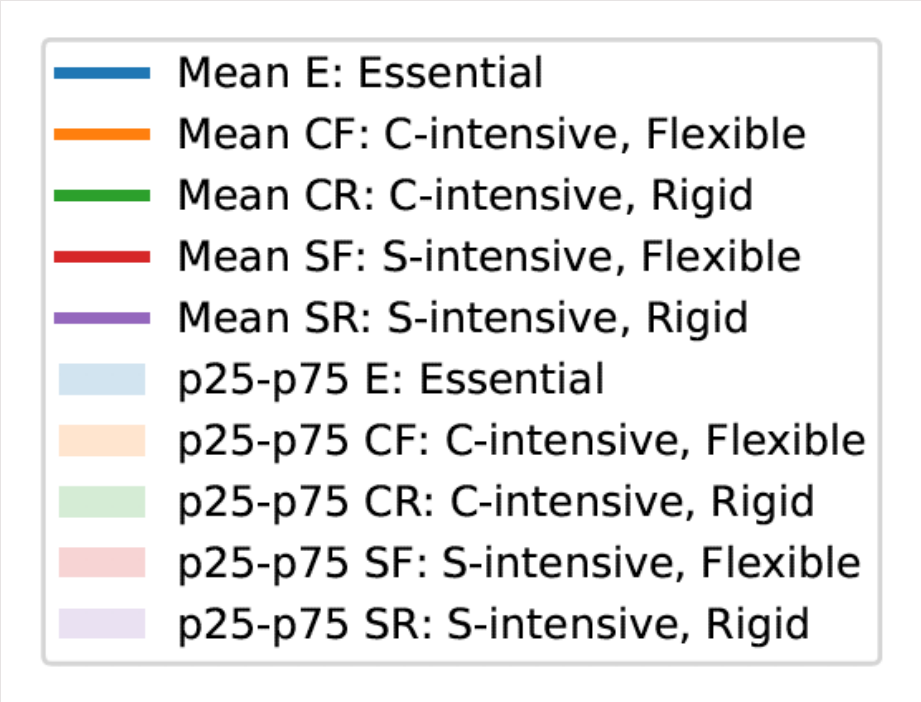
Production Possibility Frontier by Occupation





- *C*-intensive, rigid occupations (green line) hurt most by longer lockdowns

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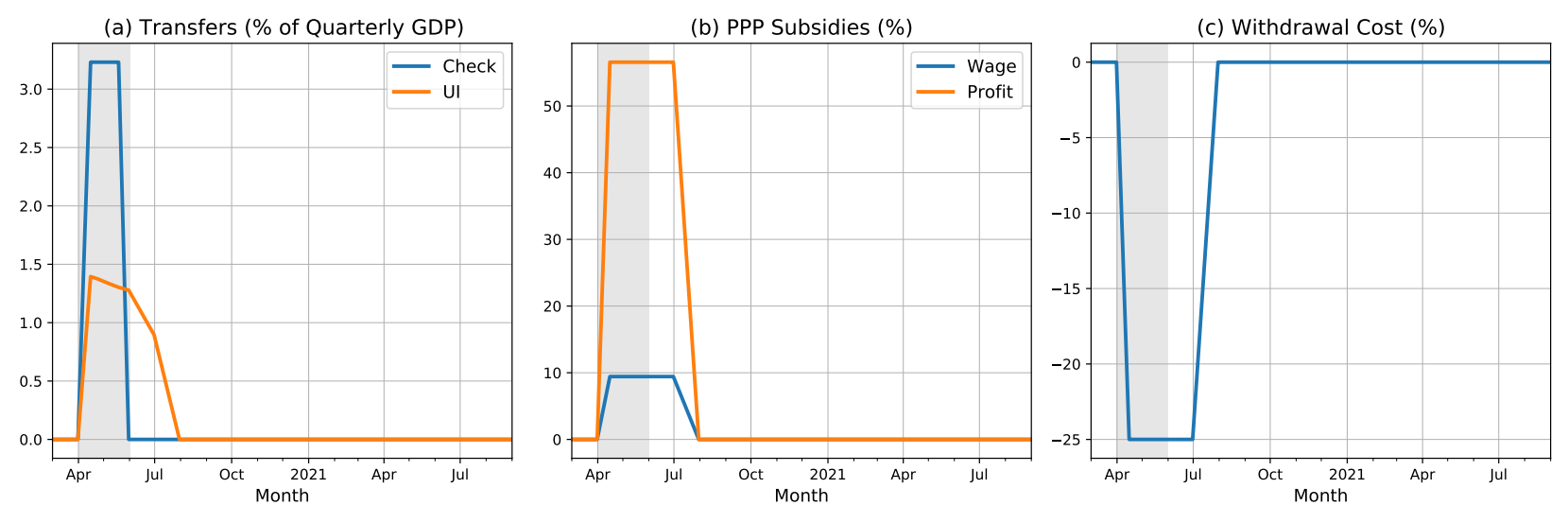
Modeling CARES Act



- Stimulus checks: unconditional transfer of $1,900 to everyone
- Pandemic UI: replacement earnings loss by decile (Ganong-Vavra)
- Paycheck Protection Program: part wage & profit subsidies (half each)
- 401(k) withdrawals up to $100,000: reduction in withdrawal cost

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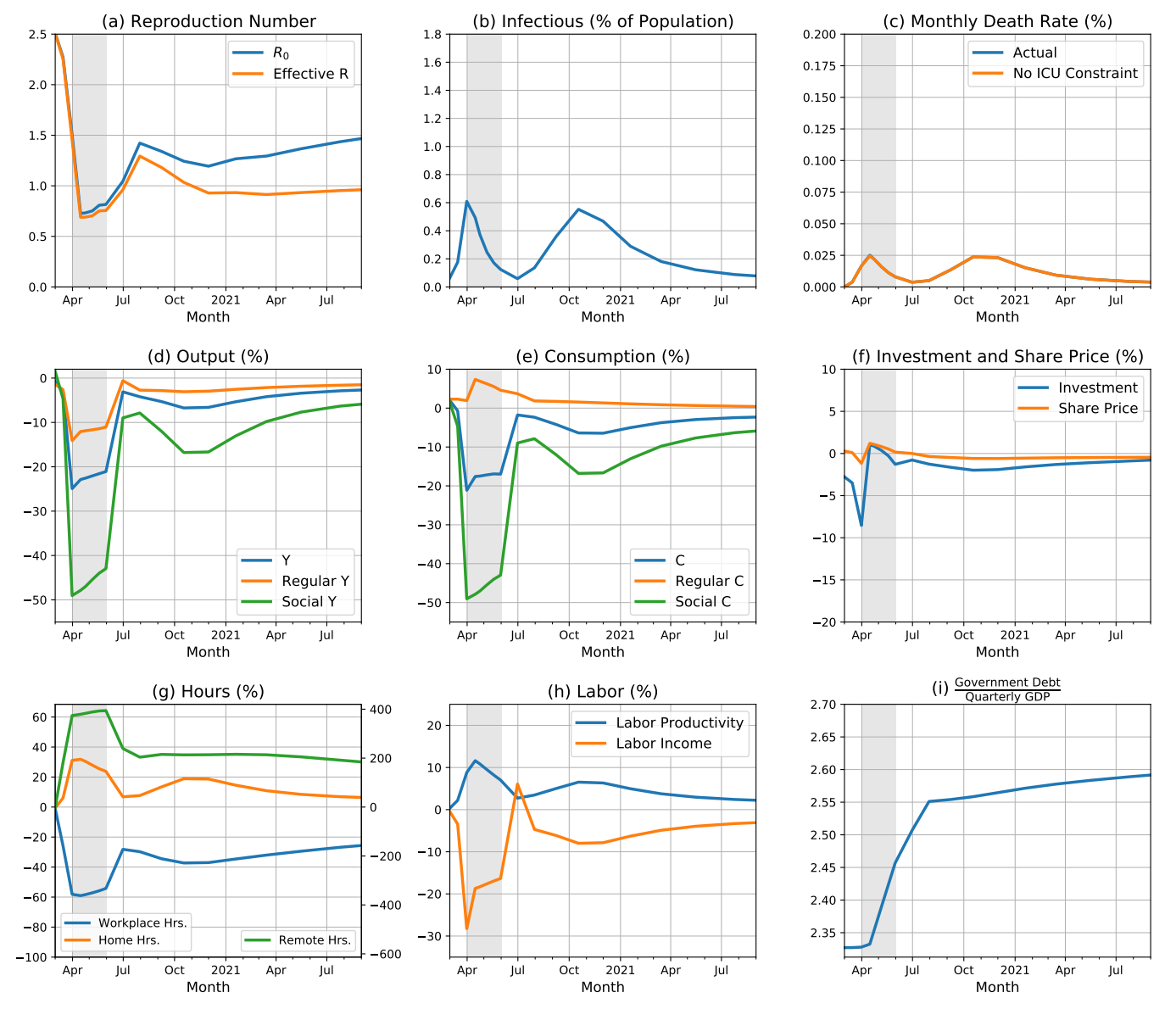
Aggregates Dynamics: Lockdown + CARES Act



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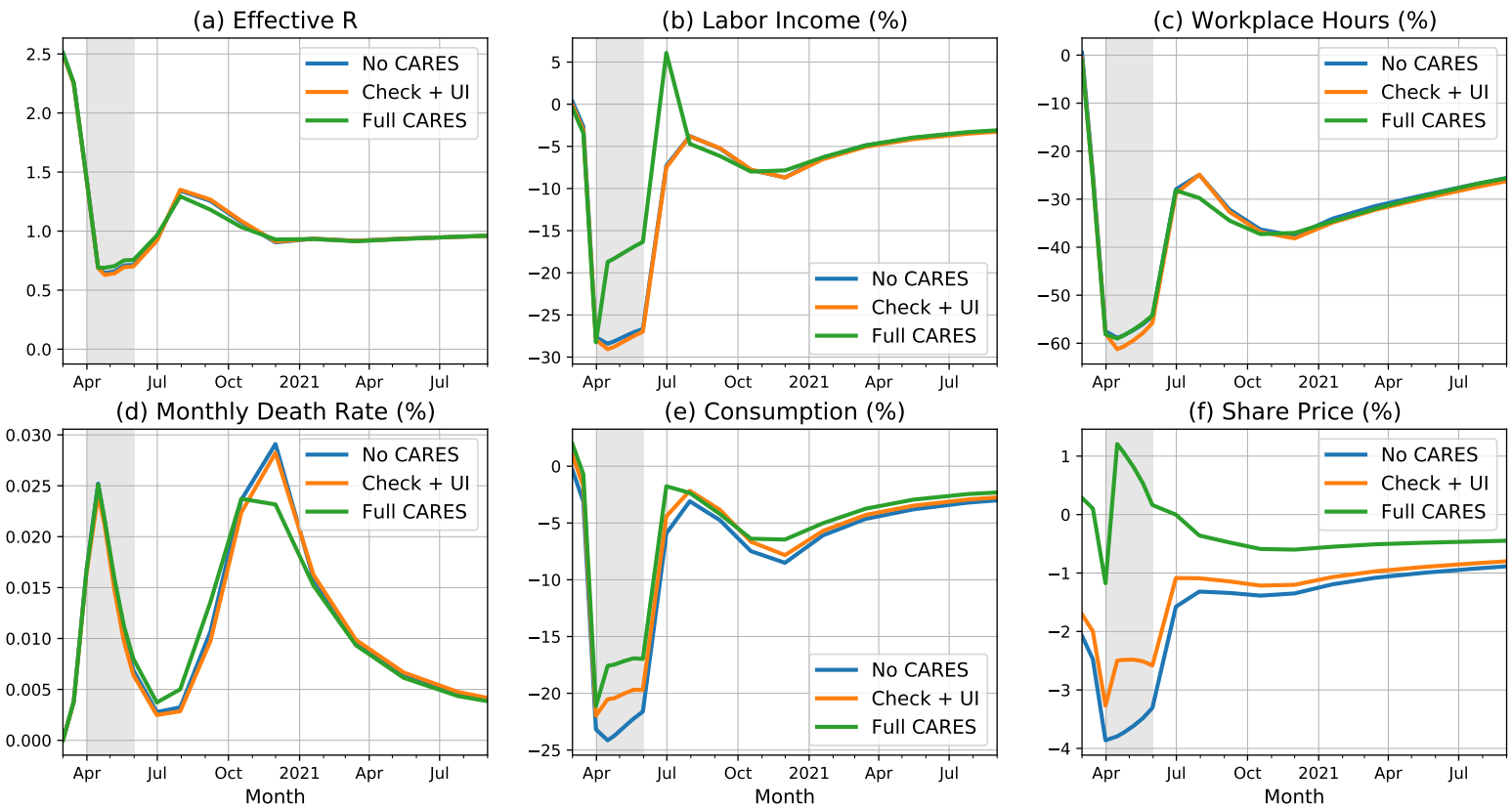
Decomposition of CARES Act Elements



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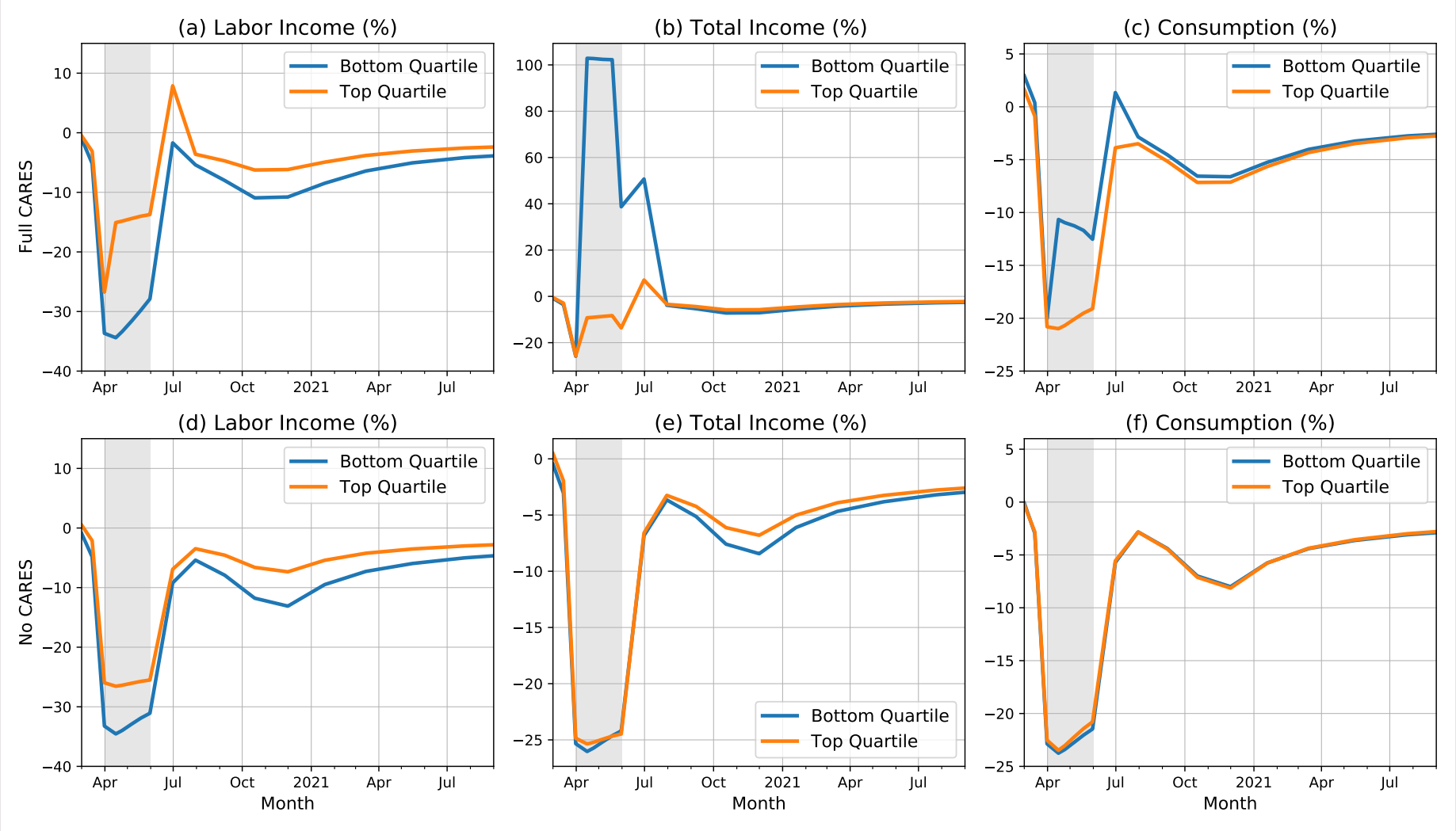
CARES Act by Income Quartile



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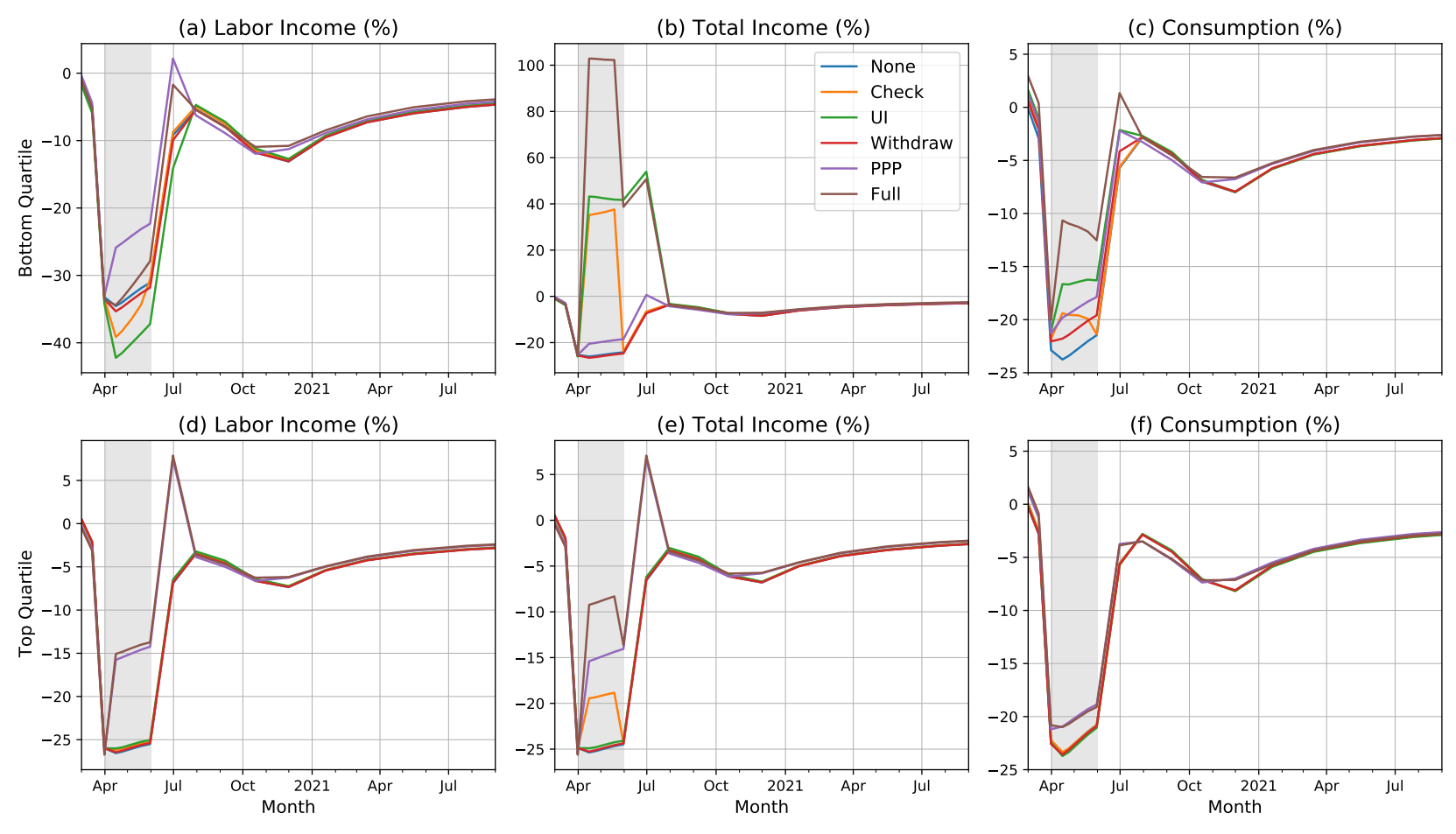
CARES Act Components by Income Quartile



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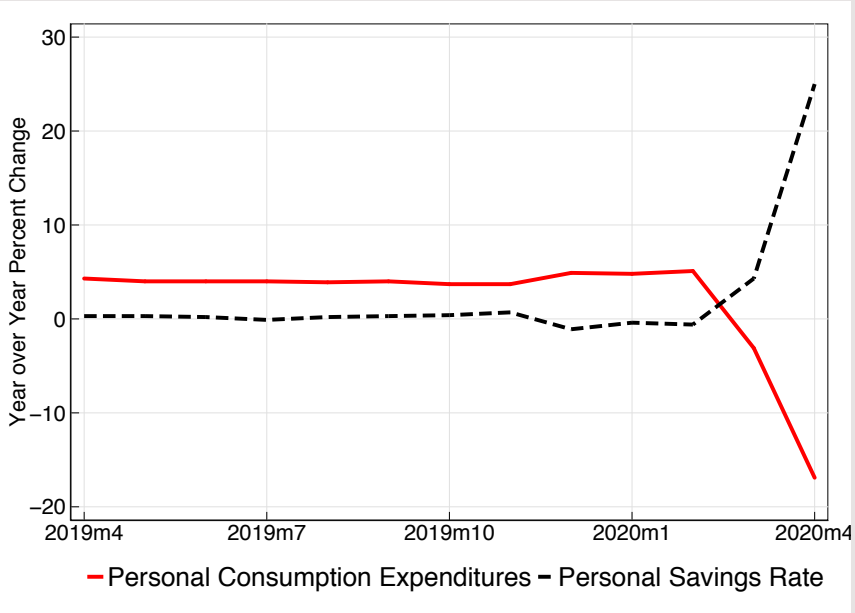
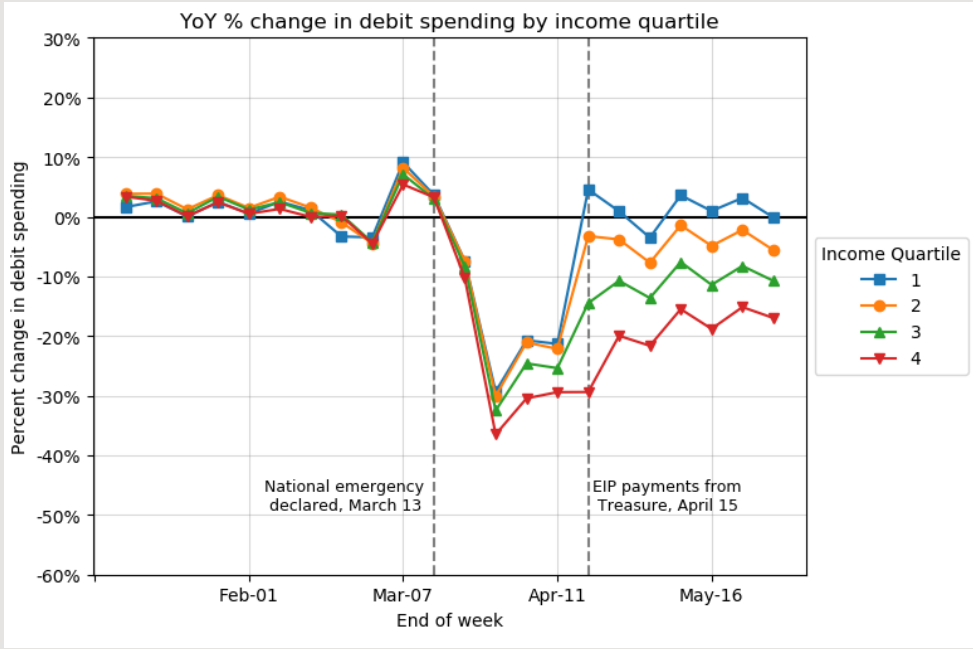
Consumption Dynamics by Income Quartile: US Data





- Source: Cox-Ganong-Noel-Vavra-Wong-Farrell-Greig
- Consumption of poor recovers faster than consumption of rich

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