Learning from Friends in a Pandemic: Social Networks and the Macroeconomic Response of Consumption

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Social networks matter for macroeconomy

Social media/networks have become a primary channel for disseminating and acquiring information

- Social influences → expectations → consumption decisions
  - Housing investment and mortgage choices (Bailey et al., 2018a, 2019; Bayer et al., 2021);
  - Stock market investment (Hong et al., 2004, 2005);
  - COVID19 and precautionary behaviors (Bailey et al., 2020)
- Other channels **not** in this paper:
  - Peer effects (Heffetz, 2011; Moretti, 2011; Bursztyn et al., 2014; De Giorgi et al., 2020)
  - Social contagion (Fowler and Christakis, 2008; Kramer et al., 2014)

Identification via a natural experiment

- Identification challenges due to reflection problem (Manski, 1993, 2000)
- What we use: the exogenous variation in the social network exposure to regional coronavirus cases
  - No endogenous network formation: predetermined social connections in 2019/2016
  - The infection in a geographically distant friend's county is exogenous given limited physical mobility during the period
  - Expectation channel >> preference channel
    - More time spent online during this period
    - Not your neighbours, less likely peer effects

This paper

1. Empirical results
   - More cases/deaths in socially connected counties → More consumption spending declines
   - Conditional on location/time FE + local cases/deaths
   - Larger declines in contact-based consumption categories
   - Heterogeneity analysis lines up with theory
2. Quantitative consumption model
   - Under incomplete market /incomplete information
   - Naive learning on social network
   - Aggregate effects depends on
     - Degree of social communication
     - Location of the initial shock
     - Asymmetry of social connections

Background

- Shock responses by consumption (Zeldes, 1989; Pistaferri, 2001; Gourinchas and Parker, 2002; Di Maggio et al., 2017; Fuster et al., 2018; Souleles, 1999; Johnson et al., 2006; Agarwal et al., 2007)
- Expectation formation via experiences/social interactions: (Carroll, 2003; Cogley and Sargent, 2008; Malmendier and Nagel, 2016; Binder and Makridis, 2020; Kuchler and Zafar, 2019; Malmendier and Nagel, 2011; Makridis, 2020; Makridis and McGuire, 2020; Malmendier et al., 2018; Giuliano and Spilimbergo, 2014; Malmendier and Shen, 2018)

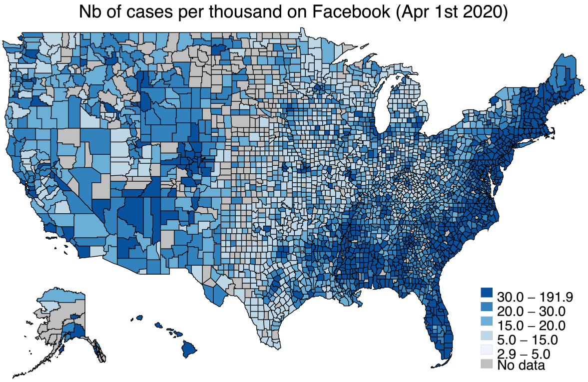
Empirical identification

Data

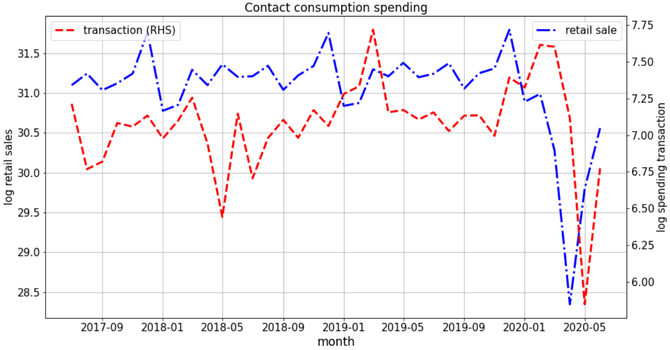
- Consumption spending (Facteus):
  - 5.18 million debit card users
  - 194 million USD daily average spending
  - 2.3 million average daily transactions
  - zip-code levels collapsed into 3051 counties
  - with MCC codes (merchant type information)
- Social network connectedness index on Facebook (SCI) (Bailey et al., 2018b)
  - Scaled pairwise friendship ties between two counties
  - based on 2019/2016 vintages

Measuring social network exposure to COVID-19

$$COVID_{ct}^{SCI} = \sum_{c'} (COVID_{c't} \times SCI_{c,c'})$$



Benchmarking consumption



Contact consumption approximated by census retail data on "drinking and eating place" and "health and personal care"

Empirical specification

We estimate panel fixed effects regressions of the form:

$$Y_{ct} = \gamma COVID^{SCI}_{ct} + \phi COVID^{d}_{ct} + \zeta_c + \lambda_t + \epsilon_{ct}$$

- γ: consumption elasticity with respect to SCI cases
- ϕ: elasticity to local coronavirus cases
- county-fixed effects + day-of-the-year fixed effects
- Robustness: controlling cases/deaths weighted by physical distance proximity
- Robustness: state $\times$ month fixed effects
- Robustness: exclude counties in the same state

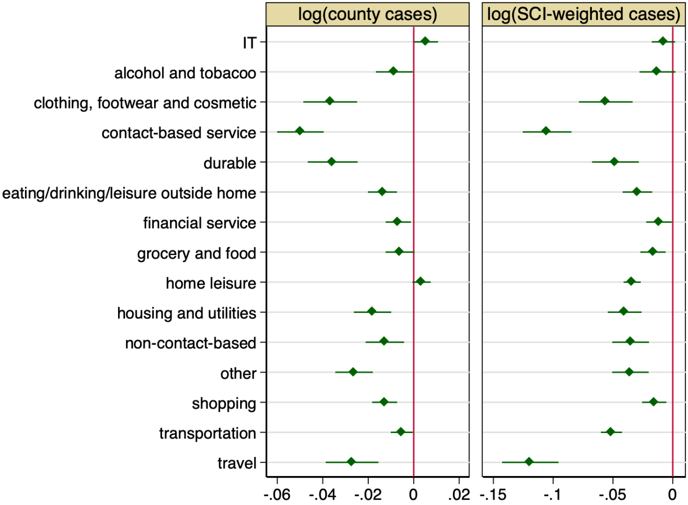
Baseline results: COVID19 cases

Dep. var. =	log(Consumption Expenditures)				
	(1)	(2)	(3)	(4)	(5)
Has SAHO			-.058***	.007	-.058***
			[.005]	[.012]	[.005]
log(SCI-weighted Cases)	-.051***	-.015*	-.014*	-.003	
	[.007]	[.008]	[.008]	[.009]	
× SAHO				-.024***	
				[.004]	
log(SCI-weighted Cases, Other States)					-.016*
					[.009]
log(County Cases)		-.015***	-.006*	-.006	-.006*
		[.004]	[.004]	[.004]	[.004]
log(County Deaths)		-.015***	-.018***	-.018***	-.017***
		[.004]	[.003]	[.003]	[.003]
R-squared	.97	.97	.97	.97	.97
Sample Size	351645	351645	351645	351645	351645
County FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
State Policies	No	No	Yes	Yes	Yes
State x Month FE	No	No	Yes	Yes	Yes

Baseline results: COVID19 deaths

Dep. var. =	log(Consumption Expenditures)				
	(1)	(2)	(3)	(4)	(5)
Has SAHO			-.056***	-.044***	-.060***
			[.005]	[.005]	[.005]
log(SCI-weighted Deaths)	-.062***	-.042***	-.062***	-.049***	
	[.008]	[.011]	[.012]	[.014]	
× SAHO				-.026***	
				[.005]	
log(SCI-weighted Deaths, Other States)					-.058***
					[.012]
log(County Cases)		-.014***	-.003	-.003	-.005
		[.004]	[.003]	[.003]	[.003]
log(County Deaths)		-.002	-.006*	-.008**	-.007*
		[.004]	[.004]	[.004]	[.004]
R-squared	.97	.97	.97	.97	.97
Sample Size	351644	351644	351644	351644	351644
County FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
State Policies	No	No	Yes	Yes	Yes
State x Month FE	No	No	Yes	Yes	Yes

Heterogeneity by consumption category



Heterogeneity in the consumption elasticity

- Larger responses in low income counties, younger counties, more populated counties
- Larger responses in counties with higher employment shares in digital-intensive and teleworking sectors

Cross-country evidence

Table 3: Consumption Responses to COVID-19 Information from Other Countries

Dep. var. =	log(spending)							
	ITA	ITA	SPA	SPA	FRA	FRA	SK	SK
log(SCI-weighted cases of the country)	-.007***		-.008***		-.011***		-.011***	
	[.001]		[.001]		[.001]		[.001]	
log(SCI-weighted deaths of the country)		-.052***		-.072***		-.014***		-.081***
		[.001]		[.001]		[.001]		[.002]
log(County Cases)	-.005	.015***	-.005	.003	-.005	-.005	-.005	.012***
	[.003]	[.004]	[.003]	[.004]	[.003]	[.003]	[.003]	[.004]
log(County Deaths)	-.004	-.025	-.004	-.019	-.004	-.004	-.004	-.025
	[.016]	[.018]	[.016]	[.018]	[.016]	[.016]	[.016]	[.018]
R-squared	.97	.98	.97	.98	.97	.97	.97	.98
Sample Size	78550	62925	78550	34148	78550	78550	78550	65552
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day FE	No	No	No	No	No	No	No	No

Learning on the social network

Belief updating via social network

- ψ_t: an aggregate state of the economy not perfectly observable and to be learned via local signals $\xi_{i,t}$

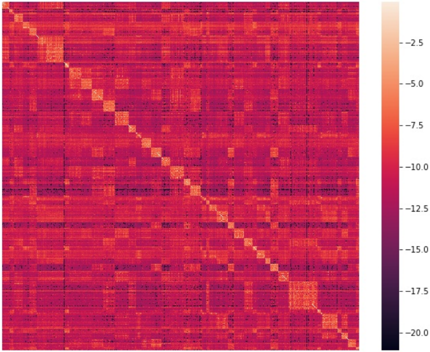
$$\tilde{\psi}_{i,t} = \underbrace{(1-\lambda)\hat{\psi}_{i,t}}_{\text{private updating}} + \underbrace{\lambda \sum_{j=1}^{N} w_{i,j}\tilde{\psi}_{j,t-1}}_{\text{social communication}}$$

$$\hat{\psi}_{i,t} = (1-k)\underbrace{\tilde{\psi}_{i,t-1}}_{\text{prior belief}} + k\underbrace{s_{i,t}}_{\text{local news}}$$

- λ: the degree of social communication
- k: individual responsiveness to local news
- $w_{i,j}$: the "listening weight" that i gives to j's belief

More Why 'Naive'? Social Network

The Listening Matrix



- The diagonal: "self-influence"
- Blocks along the diagonal: within-state influence

Aggregate belief dynamics

$$\underbrace{\tilde{\psi}_t}_{\text{N x 1}} = \underbrace{M}_{\text{N x N}} \tilde{\psi}_{t-1} + (1-\lambda)k \underbrace{s_t}_{\text{N x 1}}$$

$$\underbrace{M}_{\text{“transition” matrix}} = (1-\lambda)(1-k) \underbrace{I}_{\text{Identify matrix sized N}} + \lambda W$$

Belief dynamics depend on

- λ: the degree of social communication
- k: individual responsiveness to the news
- W: symmetry of social network More

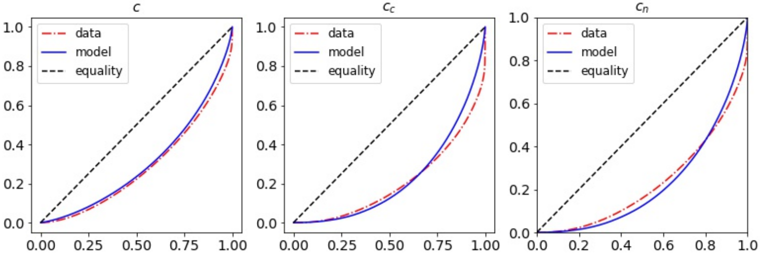
Consumption during the Pandemic

A consumption model before/during the pandemic

- Incomplete market Consumer's problem
  - uninsured income risks
  - borrowing constraints
- Local infections $\xi_{i,t}$
  - subject to aggregate spreading ψ_t and local shocks More
  - it affects
    - idiosyncratic income
    - taste torward the contact consumption More
- Incomplete information
  - about the ψ_t: aggregate $R0$ of the Covid
  - learned from local infections and social communications

Optimal consumption

Benchmark Pre-Pandemic Consumption



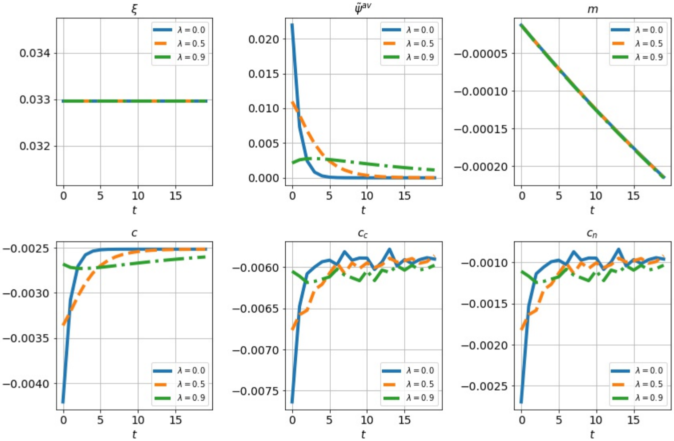
We use the cross-county standard deviation in residual total consumption of 0.89 (controlling for county population and demographics) to discipline our pre-pandemic state.

Model Calibration

Counterfactuals

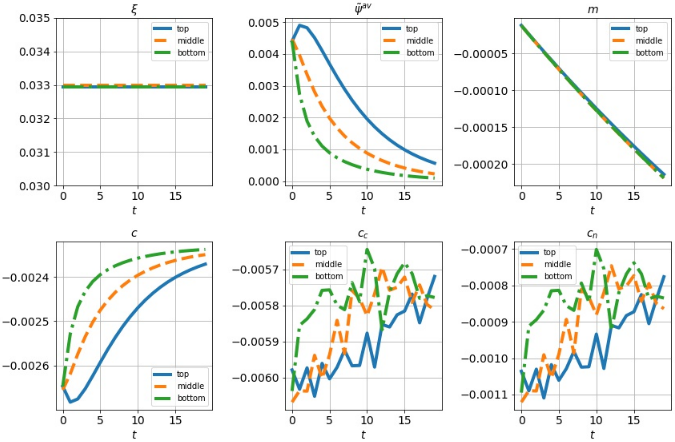
Experiment 1: Degree of social communication

Following a 10% increase in infection at one third of the influential nodes...



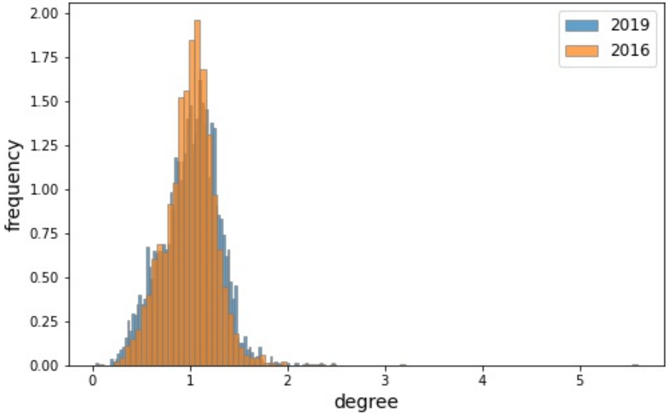
Experiment 2: location of the shock

Following a 10% increase in infection at the top/middle/bottom third agents in terms of influence...



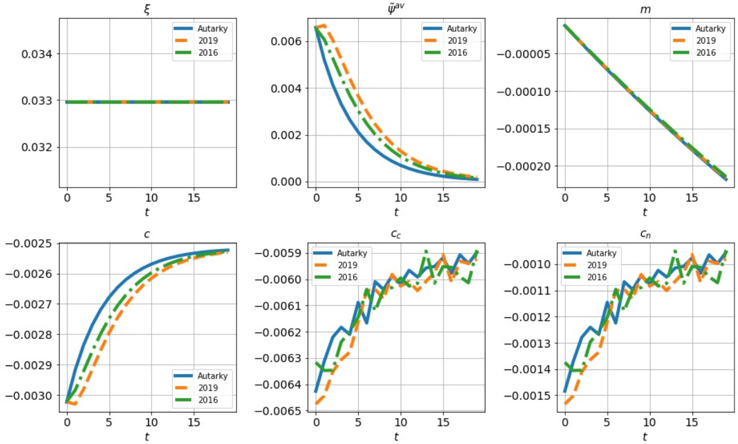
Experiment 3: Structure of the network

- $\text{std}(d_{2016}) < \text{std}(d_{2019})$
- Following a 10% increase in infection at one third of the influential nodes...



Experiment 3: Structure of the network

Following a 10% increase in infection at one third of the influential nodes...



Conclusion

Additional evidence for social network influences on economic expectations

Macroeconomic shock propagation depends on

- the degree of social communication
- the location of the shocks
- social network structure

Relation to the literature

- private updating
  - Kalman filtering/efficient learning:
    - $\kappa_{i,t}$ dynamically adjusted based on the signals' precision (Woodford, 2001)
    - stead-state gain: k^*
  - Constant-gain learning: $\kappa_{i,t} = k > 0$
    - $k < k^*$: underreaction/inattention (Mankiw and Reis, 2002; Sims, 2003; Coibion and Gorodnichenko, 2015)
    - $k > k^*$: overreaction, a la diagnostic expectation (Bordalo et al., 2020)
- social communication (SC) via naive learning (DeGroot, 1974; DeMarzo et al., 2003)
  - $\lambda = 0$: no SC
  - $\lambda = 1$: full SC
- rational benchmark (under imperfect information)
  - $\kappa_{i,t} = k^*$ and $\lambda = 0$: no SC and efficient private updating

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Social network

- "Listening matrix" W (sized $N \times N$):

$$w_{i,j} = \frac{l_{i,j}}{\sum_{k=1}^{N} l_{i,k}}$$

  - Degree $d_j = \sum_{i=1}^{N} w_{i,j}$: how influential j is in the network
  - Row sum: $\sum_{i=1}^{N} w_{i,j} = 1 \quad \forall i$
  - $w_{i,i} = 1$ if "you only have yourself as a friend"

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Why "naive"?

- Ideally: weights = true precision
- Realistically: bounded rationality
  - not knowing perfectly friend ties: who are friends' friends
  - not knowing perfectly the precision of friend's signals
  - i.e. treating them as independent signals
- Experimental evidence: (Enke and Zimmermann, 2019; Chandrasekhar et al., 2020)
- Consequence: "persuasion bias" (DeMarzo et al., 2003):
  - **inefficiency** due to dominant weights of the influencers
  - **no "wisdom of crowds"**: the converged belief (if any) of the society is not the "truth" starting from different priors
  - persistent **disagreements** in beliefs

Back

Social network and beliefs

- Key statistic: the dispersion of the degrees (always mean 1)
  - Zero dispersion (social autarky, egalitarian, or symmetric influence)

$$d_i = 1 \forall i$$

  - Non-zero dispersion (W being asymmetric)
    - Belief multiplier effect: following an exogenous shock to belief of each node, average belief response is greater than the shock Details
- Similar mechanism in the production networks (Acemoglu et al., 2012) or social multiplier via peer effects (Manski, 1993)

Back

Belief multiplier effect

- To a single node j

$$MP^j_{t+1|t} = \frac{\delta\tilde{\psi}^{av}_{t+v}/\delta\tilde{\psi}_{j,t}(\lambda \neq 0)}{\delta\tilde{\psi}^{av}_{t+v}/\delta\tilde{\psi}_{j,t}(\lambda = 0)} = (\frac{d_j}{1-k} - 1)\lambda + 1$$

  - $MP^j_{t+1|t} > 1$ if $d_j + k > 1$ and $\lambda > 0$
- To all the nodes

$$MP_{t+v|t} = \frac{1}{N}\sum_{j=1}^{N} MP^j_{t+v|t} = \Theta^v$$

$$\Theta = 1 + \frac{k\lambda}{1-k}$$

  - $MP_{t+v|t} > 1 \quad \forall 0 < k < 0 \quad \text{and} \quad \lambda > 0$

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Consumer's problem

- N agents/consumers/nodes: $i = 1, 2 \ldots N$
- Utility

$$\max_{\{c_{i,c,t}, c_{i,n,t}\}} \quad E_0 \sum_{t=0}^{\infty} \beta^t u(c_{i,t})$$

$$u(c) = \frac{c^{1-\rho}}{1-\rho}$$

$$c_{i,t} = (\underbrace{\tau_{i,t}}_{\text{taste shifter}} \phi_c c_{i,c,t}^{\frac{\epsilon-1}{\epsilon}} + (1-\phi_c) c_{i,n,t}^{\frac{\epsilon-1}{\epsilon}})^{\frac{\epsilon}{\epsilon-1}}$$

- Budget/borrowing constraints

$$c_{i,t} + a_{i,t} = \underbrace{m_{i,t}}_{\text{cash in hand}} = \underbrace{y_{i,t}}_{\text{labor income}} + \underbrace{a_{i,t-1}(1+r)}_{\text{bank balance}}$$

$$a_{i,t} \geq 0$$

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The pandemic

- Local infection:

$$\xi_{i,t} = \underbrace{\psi_t}_{log(R0_t)} + \xi_{i,t-1} + \underbrace{\eta_{i,t}}_{\text{shock}} \quad \eta_{i,t} \sim N(-\frac{\sigma_\eta^2}{2}, \sigma_\eta^2)$$

$$\psi_{t+1} = \psi_t + \theta_t \quad \theta_t \sim N(-\frac{\sigma_\theta^2}{2}, \sigma_\theta^2)$$

Back

The pandemic and the economy

- Income:

$$y_{i,t} = o_{i,t} z_{i,t}$$

$$ln(o_{i,t}) = ln(o_{i,t-1}) + \underbrace{v_{i,t}}_{\text{permanent}} \qquad v_{i,t} \sim N(-\frac{\sigma_v^2}{2}, \sigma_v^2)$$

$$ln(z_{i,t}) = \underbrace{\alpha_z}_{\leq 0} \xi_{i,t} + \underbrace{\zeta_{i,t}}_{\text{transitory}} \qquad \zeta_{i,t} \sim N(-\frac{\sigma_\tau^2}{2}, \sigma_\tau^2)$$

- Taste shifter:

$$ln(\tau_{i,t}) = \overbrace{\alpha_s}^{\leq 0} \xi_{i,t} + \mu_{i,t} \quad \mu_{i,t} \sim N(-\frac{\sigma_\mu^2}{2}, \sigma_\mu^2)$$

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Optimal consumption

$$V_{i,t}(m_{i,t}, o_{i,t}, \underbrace{\tilde{\psi}_{i,t}}_{\text{Perception}}, \tau_{i,t}) = \max_{\{c_{i,c,t}, c_{i,n,t}\}} u(c(c_{i,c,t}, c_{i,n,t})) + \beta \tilde{E}_{i,t} V_{i,t+1}(m_{i,t+1}, o_{i,t+1}, \psi_{t+1}, \tau_{i,t+1})$$

- Inter-temporal:

$$V_{i,t}(m_{i,t}, o_{i,t}, \tilde{\psi}_{i,t}) = \max_{\{c_{i,t}\}} u(c_{i,t}) + \beta \tilde{E}_{i,t} V_{i,t+1}(m_{i,t+1}, o_{i,t+1}, \psi_{t+1})$$

- Intra-temporal allocation:

$$\frac{\tau_{i,t}\phi_c}{1-\phi_c}\left(\frac{c_{i,c,t}}{c_{i,n,t}}\right)^{-\frac{1}{\epsilon}} = 1$$

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Calibration

Parameters	Value	External source/restriction
	Preference	
ϕ_c	0.41	Estimated from CEX
ϵ	0.75	Estimated from CEX
ρ	2	Standard in literature
β	$0.99^{1/4}$	Standard in literature
$1+r$	$1.02^{1/4}$	Standard in literature
	Stochastic Income/Preference Shocks	
σ_v^2	0.01 $\times 4/11$	Match pre-pandemic consumption inequality
σ_ζ^2	0.014,	Match pre-pandemic consumption inequality
σ_μ^2	2.90	Match pre-pandemic sub-category consumption
	COVID19 Dynamics	
σ_θ	0.121	County panel estimation of COVID19 cases
σ_η	0.209	County Panel estimation of COVID19 cases
	Elasticity of Income/Preference to Infection	
α_z	-0.1	Externally estimated
α_s	-0.2	Match the subcategory consumption response

Back

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