The Macroeconomics of Pandemics in Developing Countries: an Application to Uganda

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TARC Workshop 'COVID-19 and Developing Countries'
June 19$^{th}$, 2020
Lockdown stringency across countries

![Graph showing the OxCGRT Stringency Index for different countries and income levels over time from January 1 to June 1. The countries include the United States, Uganda, High Income, Upper Middle Income, Lower Middle Income, and Low Income. The graph illustrates the increase in stringency indices during the pandemic period and the subsequent easing of restrictions.]
Motivation

- Similar measures against COVID-19 pandemic across countries
- Early models of the pandemic justified widespread restrictions
  - Eichenbaum et al. (2020); Farboodi et al. (2020); Glover et al. (2020)
- Emerging evidence of economic hardship through lockdowns
  - Mahmud and Riley (2020); Moscoviz and Le Nestour (2020); Brac (2020)
- Development economists critical of chosen policies
  - Ray and Subramanian (2020); Barnett-Howell and Mobarak (2020); Ravallion (2020)

⇒ Do mortality risks differ across countries?
⇒ Do welfare-optimizing policies differ across countries?
Predicting infection fatality rates for COVID-19

- How to estimate the share of infected that may die from the disease (IFR) in a country if one doesn’t know...?
  - ... the true number of COVID-19 infected
  - ... nor the true number of COVID-19 deaths
- We rely on medical data from high-income countries and account for different...
  - ... age-sex distributions
  - ... comorbidities
  - ... health system capacities
- Using Bayes Rule, we can estimate the IFR conditional on age (a), sex (s) and comorbidities (c)

$$cIFR = P_{las}(d|c) = \frac{P_{las}(c|d)}{P_{las}(c)} P_{las}(d)$$
Predicted infection fatality rates for COVID-19

Based on demography, comorbidities, and health system capacity

Source: Ghisolfi et al (2020)
Do welfare-optimizing policies differ across countries?

- We build on recent contributions on welfare maximizing policy in the United States (Eichenbaum, Rebelo, Trabandt, 2020).
- We calibrate and extend their model to better reflect dimensions important in developing countries:
  - Lower incomes (GDP/capita at $710 in Uganda, $54,000 in US) & subsistence constraints
  - IFRs calculated for Uganda (age, comorbidities, health system)
  - Access to vaccines
- How do implications of the model differ when using different valuations of life?
Epidemic part is a **Susceptible-Infected-Recovered** model (t=1 week)

\[ S_{t+1} = S_t - \pi_i S_t I_t \]
\[ I_{t+1} = (1 - \pi_r) I_t + \pi_i S_t I_t \]
\[ R_{t+1} = R_t + \pi_r I_t \]
\[ D_{t+1} = D_t + \pi_d I_t \]

How much agents consume and work affects infections

\[ I_{t+1} = (1 - \pi_r) I_t + \pi_i (S_t C_t^s) \left( I_t C_t^i \right) \]
\[ + \pi_i (S_t N_t^s) \left( I_t N_t^i \right) \]
\[ + \pi_i S_t I_t \]
ERT model combines epidemic and economic components

Epidemic part is a Susceptible-Infected-Recovered model (t=1 week)

\[
\begin{align*}
S_{t+1} &= S_t - \pi_i S_t I_t \\
I_{t+1} &= (1 - \pi_r) I_t + \pi_i S_t I_t \\
R_{t+1} &= R_t + \pi_r I_t \\
D_{t+1} &= D_t + \pi_d I_t
\end{align*}
\]

How much agents consume and work affects infections

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I_{t+1} = (1 - \pi_r) I_t + \pi_i \left( S_t C_t^s \right) \left( I_t C_t^i \right) + \pi_i \left( S_t N_t^s \right) \left( I_t N_t^i \right) + \pi_i S_t I_t
\]

Infections from consuming

Infections from working

Infections from random interactions
Key assumptions of the model

- Agents’ consumption cannot fall below a certain level
  \[ u(c_t, n_t) = \ln (c_t - \bar{c}) - \frac{\theta}{2} n_t^2 + \bar{u} \]

- Agents realize the likelihood and dangers of getting infected
  - voluntary reductions in economic activity to reduce infection risk

Susceptible:  \[ U^s_t = u(c^s_t, n^s_t) + \beta \left[ (1 - \tau_t) U^s_{t+1} + \tau_t U^i_{t+1} \right] \]
  where:  \[ \tau_t = \pi_{s1} c^s_t (I_t C_t) + \pi_{s2} n^s_t (I_t N_t) + \pi_{s3} I_t \]

Infected:  \[ U^i_t = u(c^i_t, n^i_t) + \beta \left[ (1 - \pi_r - \pi_d) U^i_{t+1} + \pi_r U^r_{t+1} \right] \]

Recovered:  \[ U^r_t = u(c^r_t, n^r_t) + \beta U^r_{t+1} \]

- But they neglect their contribution to spreading the epidemic
  - potential efficiency gain through lockdown policy
Model

- The government sets a containment rate
  - ’measures aimed at reducing interactions’ which affect consumption
  - modeled via agents’ budget constraint
    \[(1 + \mu_{ct}) c_t = w_t n_t + \Gamma_t\]

⇒ What timepath of containment maximizes aggregate utility?

### Calibration

<table>
<thead>
<tr>
<th></th>
<th>Uganda</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income/year</td>
<td>$535</td>
<td>$58,000</td>
</tr>
<tr>
<td>Hours worked/week</td>
<td>50</td>
<td>28</td>
</tr>
<tr>
<td>Subsistence level</td>
<td>$200</td>
<td>$0</td>
</tr>
<tr>
<td>Value of statistical life</td>
<td>$31,000(^a)</td>
<td>$9.6 million</td>
</tr>
<tr>
<td>IFR</td>
<td>0.33%</td>
<td>0.79%</td>
</tr>
</tbody>
</table>

\(^a\text{VSL}_{US} \times \frac{\text{GDP}_{UG}}{\text{GDP}_{US}} \times \frac{\text{Health Spending}_{UG}/\text{GDP}_{UG}}{\text{Health Spending}_{US}/\text{GDP}_{US}}\)
Benchmark calibration to US

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Calibration to Ugandan economy & IFR

![Graphs showing infected, susceptibles, aggregate consumption, recovered, and deaths over weeks, with different calibration scenarios including SIR, US calibration, Macro-SIR, and optimal policy.]

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Summary of calibration steps

Death reduction vs. SIR model
- voluntary adjustment
- + containment policy

First-year consumption reduction
- voluntary adjustment
- + containment policy

Scenario | Economy | IFR | Subs. level | VSL
--- | --- | --- | --- | ---
I | US | US (0.8%) | no | $9.6m
II | US | UG (0.3%) | no | $9.6m
III | UG | US (0.8%) | no | $31k
IV | UG | UG (0.3%) | no | $31k
V | UG | UG (0.3%) | $200 | $31k

US (0.8%) | US (0.8%) | US (0.8%) | US (0.8%) | US (0.8%)

Waiting for a vaccine?

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Valuations of life

- How to think of a valuation of life?
  - Lost utility.
  - Is there a relevant number to target?
  - Revealed preferences by authorities?
    - For the US we have such a number: $9.6$ mill.
    - For Uganda: scale to spending on health per capita.
Valuations of life

Death reduction vs. SIR model

- Voluntary adjustment
- + containment policy

Death reduction

First-year consumption reduction

Scenario | I | II | III | IV | V | VI | VII
---|---|---|---|---|---|---|---
Economy | US | US | UG | UG | UG | UG | UG
IFR | US (0.8%) | UG (0.3%) | UG (0.8%) | UG (0.3%) | UG (0.3%) | UG (0.3%) | UG (0.3%)
Subs. level | no | no | no | no | $200 | $200 | $200
VSL | $9.6m | $9.6m | $31k | $31k | $31k | $85k\(^1\) | $120k\(^2\)

\(^1\) proportional to GDP/capita wrt US

\(^2\) following Viscusi and Masterman (2017)
Conclusion & next steps

- Based on a simple economic framework, the same logic that justifies strict containment policies in the US suggests more lenient measures in poorer and younger countries.

- So why do we see lockdowns everywhere?
  - Uncertainty around the epidemic - what should measures be going forward?
  - Do individuals fear the virus more than necessary, and thus demand strong action?
  - Do governments have different preferences over the relation between deaths and utility of the living?

- A caveat: VSLs
References I


Waiting for a vaccine?

- What if governments imposed strict lockdowns because they think a treatment or a vaccine may come?
- So far in the model, the only way out of the epidemic is herd immunity
- How does optimal policy change if we hope for a vaccine to arrive?
- Agents now expect that in every period, a vaccine may become available with a certain probability
Waiting for a vaccine?

- Infected, I
- Aggregate Consumption, C
- Deaths, D
- Containment Policy, $\mu_c$

Legend:
- SIR
- US calibration
- Uganda calibration
- +vaccine within a year
- +vaccine within two years