Deadly Debt Crises: COVID-19 in Emerging Markets

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The views expressed here are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.
Motivation

- Pandemic presents huge challenges: deadly and highly contagious disease
  - Countries are imposing lockdowns to control the disease and save lives
  - Advanced economies engaging in large fiscal transfers to insure citizens

- For emerging markets pandemic brings additional problems (Hevia-Neumeyer 2020)
  - Debt crisis: Many already indebted, rising interest rates, looming defaults
  - Limited fiscal space: Difficult to support citizens during lockdowns
  - Large external shock: collapses in export demand, tourism, remittances, capital flows

Health crisis + economic crisis + debt crisis
COVID-19 in Emerging Economies: Daily Fatalities

As of August 23rd, since 3 fatalities

- Growing epidemic in emerging markets
- Large human cost, 800,000+ official deaths thus far
- Likely many more actual deaths (excess/official deaths = 2 in Turkey, 15 in Ecuador)
Sovereign Spreads

- Already in default: Argentina, Ecuador, Lebanon
- CDS spreads have risen 200-400 bp for Mexico, Brazil, Russia, Turkey
Epidemic can generate debt crises: defaults and high spreads

Debt crises increase fatalities: makes lockdowns more costly

- Economic Output
- Debt Low default
- Health
- Consumption
- Life
Debt Crisis and the Epidemic

Epidemic can generate debt crises: defaults and high spreads

COVID-19

- Economic Output
- Low default
- Consumption

Debt crises increase fatalities: makes lockdowns more costly

- Health Crisis
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COVID-19

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Economic Output

Debt Low default

Health Crisis

Consumption

Life

Lockdowns
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Economic Crisis

Debt Crisis

Health Crisis

Consumption

Life

COVID-19

Lockdowns
Debt Crisis and the Epidemic

Epidemic can generate debt crises: defaults and high spreads

Debt crises increase fatalities: makes lockdowns more costly

Less Lockdowns

COVID-19

Economic Crisis

Debt Crisis

Health Crisis

Consumption

Life
Debt Crisis and the Epidemic

Epidemic can generate debt crises: defaults and high spreads

Debt relief positive social value: alleviates debt crisis and saves lives

Debt crises increase fatalities: makes lockdowns more costly

More Lockdowns

Lockdowns

Debt Relief

COVID-19

Economic Crisis

Debt Lower Default

Health Crisis

Consumption

Life
Quantitative Findings

- Epidemic generate long debt crisis
  - Leads to debt crisis of 43 months with large defaults and rising spreads
  - Optimal lockdown: starts 2 months in; lasts for 8 months; 2 months high 50% intensity
  - Lockdown reduces fatalities by half
  - Welfare loss of 1.8% in consumption equivalence

- Less debt at epidemic outbreak
  - Can use borrowing to support consumption and avoid debt crisis
  - Allows more severe mitigation that saves lives

- Debt relief has positive social value
  - Program of 10% (break-even) benefits the country by 9.4% in present value
  - Country gains from avoiding debt crisis and reducing fatalities
  - Even greater benefits: longer term loan, higher grant component
Literature


**Epidemic risks severe sovereign debt crisis**


**Debt relief with positive social value: avoid debt crisis and save lives**
Model

- Small open economy with government and homogeneous consumers
- Economy is hit by unexpected epidemic
  - Dynamics follow a standard epidemiological SIR model
- Government: borrows internationally, can default on its debt, decides on lockdowns
  - Both default and lockdowns are of endogenous intensity and length
- Analyze dynamics during epidemic
  - Population groups: susceptible, infected, recovered, deceased
  - Consumption, lockdowns, and output
  - Debt, default episodes (length & intensity), sovereign spreads
- Debt relief counterfactuals
Preferences and Technology

The government values consumption and life

\[ v_0 = \sum_{t=0}^{\infty} \beta^t \left( u(c_t) - \chi \phi_t^D \right) \]

- \( c_t \) is per capita consumption, \( \phi_t^D \) are fatalities, \( \chi \) value of life

Output \( Y_t \) depends on productivity, lockdowns \( L_t \), and population \( N_t \)

\[ Y_t = z_t (1 - L_t) N_t \]

- Productivity of labor economy-wide is \( z_t \)
Government Debt and Default

- Use international debt operations to support consumption
  \[ Y_t + q_t \ell_t = N_t c_t + (1 - d_t)B_t \]

- Borrows at price \( q_t \) and can default on its debt \( B_t \) with intensity \( d_t \)

- Default leads to loss of productivity proportional to intensity \( z_t = \tilde{z}\phi(d_t) \)

- Fraction \( \kappa \) of defaulted debt accumulates and increases future debt obligations
  \[ B_{t+1} = \ell_t + \kappa d_t B_t \]

- Risk neutral lenders discount at world rate \( r \) and break even in expected value
  \[ q_t = \frac{1}{1 + r} [(1 - d_{t+1}) + d_{t+1} \kappa q_{t+1}] \]

More default with high debt, low output, and low bond price (due to low repayment prospects)
Epidemic Dynamics: Standard SIR

- Population transits from susceptible, to infected, to recovered or deceased

\[ \mu^S \rightarrow \mu^I \rightarrow [\mu^R \text{ or } \mu^D] \]

- Key building block newly infected \( \mu_i^x \): transition from susceptible to infected

\[ \mu_i^x = \pi_x \mu_i^I \mu_i^S \]

Probability becoming infected depends on already infected \( \mu_i^I \) and \( \pi_x = R_0(1 - \pi_I) \)

- Susceptibles shrink with infections

\[ \mu_{i+1}^S = \mu_i^S - \mu_i^x. \]

- Infected evolve according to newly infected and past infected with probability \( \pi_I \)

\[ \mu_{i+1}^I = \pi_I \mu_i^I + \mu_i^x \]

- Infected die at rate \( \pi_D(\mu_i^I) \) (healthcare capacity constraints)

\[ \mu_{i+1}^D = \mu_i^D + \pi_D(\mu_i^I)\mu_i^I \]

\[ \mu_{i+1}^R = \mu_i^R + [1 - \pi_I - \pi_D(\mu_i^I)]\mu_i^I \]
Epidemic Dynamics: SIR and Lockdowns

Based on Alvarez-Argente-Lippi 2020

- Lockdown policy of size $L_t$ reduces population for contagion by a fraction $\theta L_t$

- Fewer newly infected $\mu^x_t$ with lockdowns

$$\mu^x_t = \pi_x \left( (1 - \theta L_t) \mu^I_t \right) \left( (1 - \theta L_t) \mu^S_t \right)$$

Lockdowns alter the dynamics of the epidemic
Government Problem During Epidemic

- State variables during epidemic are groups $\mu_t = (\mu^S_t, \mu^I_t, \mu^D_t)$ and debt $B_t$
- Government chooses borrowing $B_{t+1}$, default $d_t$, and lockdowns $L_t$

$$V_t(\mu_t, B_t) = \max_{B_{t+1}, d_t, L_t} u(c_t) - \chi \phi^D_t + \beta V_{t+1}(\mu_{t+1}, B_{t+1})$$

- subject to the SIR dynamics which determine $\mu_{t+1}(\mu_t, L_t)$ with $\phi^D_t = \pi_D(\mu^I_t)\mu^I_t$,
- the resource constraint with population $N_t = (1 - \mu^D_t)$

$$N_t c_t + (1 - d_t) B_t = z_t N_t (1 - L_t) + q_t(B_{t+1}, \mu_{t+1})(B_{t+1} - \kappa d_t B_t),$$

- bond pricing depends on epidemic $q_t(B_{t+1}, \mu_{t+1})$
Government Problem During Epidemic

- State variables during epidemic are groups $\mu_t = (\mu_t^S, \mu_t^I, \mu_t^D)$ and debt $B_t$
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- the resource constraint with population $N_t = (1 - \mu_t^D)$

$$N_t c_t + (1 - d_t) B_t = z_t N_t (1 - L_t) + q_t (B_{t+1}, \mu_{t+1}) (B_{t+1} - \kappa d_t B_t),$$

- bond pricing depends on epidemic $q_t (B_{t+1}, \mu_{t+1})$

Epidemic generates debt crises: low output and low repayment prospects $\rightarrow$ defaults

Debt crises can increase death toll: makes lockdowns more costly
Dynamic Program

Government problem with state $\mu_t = (\mu^S_t, \mu^I_t, \mu^D_t)$ and debt $B_t$

$$V_t(\mu_t, B_t) = \max_{B_{t+1}, d_t, L_t} u(c_t) - \chi \pi_D(\mu^I_t)\mu^I_t + \beta V_{t+1}(\mu_{t+1}, B_{t+1})$$

subject to population $N_t = (1 - \mu^D_t)$

resource constraint $N_t c_t + (1 - d_t)B_t = z_t N_t (1 - L_t) + q_t(B_{t+1}, \mu_{t+1})(B_{t+1} - \kappa d_t B_t)$

SIR dynamics

$$\mu^x_t = \pi_x (1 - \theta L_t) \mu^I_t (1 - \theta L_t) \mu^S_t$$

$$\mu^I_{t+1} = \pi_I \mu^I_t + \mu^x_t$$

$$\mu^S_{t+1} = \mu^S_t - \mu^x_t.$$  

$$\mu^D_{t+1} = \mu^D_t + \pi_D(\mu^I_t)\mu^I_t$$

bond price function: $q_t(B_{t+1}, \mu_{t+1}(\mu_t, L_t)) = \frac{1}{1 + r} \{(1 - d_{t+1}) + \kappa d_{t+1} q_{t+1}(B_{t+2}, \mu_{t+2})\}.$
Parameter Values

SIR Parameters: Diamond Princess estimates, recent literature

- Fatality rate increases with infected to capture congestion in the health care system:

\[ \pi_D(\mu^I_t) = \pi_D^0 + \pi_D^1 \mu^I_t \]

- \( R_0 = 2.28 \) and \( \pi_D^0 = 0.005(1 - \pi_I) \) from Diamond Princess; \( \pi_I \) to disease length 18 days; \( \pi_D^1 = 0.18\% \), \( \theta = 0.5 \) (Alvarez-Argente-Lippi)

- \( \chi \): VSL estimates for emerging markets Viscusi and Masterman (2017)
  VSL = 230\( \times \)c per capita adjusted to 20 years loss (in US 9.6 million is 207\( \times \)c)

Debt parameters: 30% debt to output, recent literature

- Default cost increasing in default intensity, parameters from Arellano-MateosPlanas-RiosRull

\[ \phi(d) = [1 - \gamma_0d^{\gamma_1}](1 - \gamma_2\mathbb{1}_{d > 0}) \]

- Mean debt maturity 6 years, mean recovery 54% (Trebesch-Cruces), \( r = 1\% \) annual, \( \beta \) for 2% domestic real rate

Others: CRRA of 2, weekly model
Quantitative Experiments

Baseline economy:

- Policy rules: default, lockdown
- Time paths: epidemic groups, lockdowns, fatalities, consumption, defaults

The role of debt at the time of outbreak:

- Less initial debt: improves epidemic outcomes, shorter crisis

Debt relief counterfactuals:

- Design of loan and/or grant programs
- Large social value
Policy rules: Lockdown and default

More *infected* or *susceptible* leads to
- Lockdowns – benefits highest, disease very contagious
- Default – With low output from lockdowns higher default incentives
Policy rules: Lockdown and debt

- Less lockdown with higher debt – too costly when debt crisis looms
Time Paths: Epidemic groups

- Optimal lockdowns lower peak of infections from 20% to 8%
- Fraction of ever infected decreases from 88% to 70%
Time Paths: Lockdowns reduce fatalities

- Fatalities reduced from 1% with no lockdowns to .5%
- Optimal lockdown: start 2 months after outbreak, lockdowns for 8 months; 3.5 months of intensity above 40%
- Depress consumption and output (15% drop first year)
- Generate debt crisis: default episode of 43 months
  - Default upon outbreak
  - Intense default during lockdown to support consumption, results in higher future debt
  - Default is prolonged because of persistently high debt
Baseline economy paths

Deceased (D, %)

Infected (I, %)

Susceptible (S, %)

Lockdown (L, %)

Consumption and Output

Partial Default (d, %)

Spread (CDS, bps)

Debt (B, %)

Economic crisis + debt crisis + health crisis
## Epidemic Outcomes

<table>
<thead>
<tr>
<th>Crisis</th>
<th>Baseline</th>
<th>No lockdown</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Health crisis</strong></td>
<td>Deceased (% Pop)</td>
<td>0.50</td>
</tr>
<tr>
<td><strong>Economic crisis</strong></td>
<td>Lockdown</td>
<td></td>
</tr>
<tr>
<td>Length (months)</td>
<td>7.8</td>
<td>0</td>
</tr>
<tr>
<td>Intensity, max (%)</td>
<td>51</td>
<td>–</td>
</tr>
<tr>
<td>Output loss (%)</td>
<td>–19</td>
<td>0</td>
</tr>
<tr>
<td><strong>Debt crisis</strong></td>
<td>Default</td>
<td></td>
</tr>
<tr>
<td>Length (months)</td>
<td>43</td>
<td>–</td>
</tr>
<tr>
<td>Intensity, max (%)</td>
<td>55</td>
<td>–</td>
</tr>
<tr>
<td><strong>Welfare losses</strong></td>
<td>Country CE present value (% output)</td>
<td>–87</td>
</tr>
<tr>
<td>Lender (% output)</td>
<td>–1.2</td>
<td>0</td>
</tr>
</tbody>
</table>

- Lockdown for 8 months with max intensity of 55%; output 19% lower
- Long debt crisis: 43 months with defaults
- Costs: large for country, 87% of output in CE (flow of 1.8% of consumption) & small for lenders
Epidemic Outcomes: Debt Matters

Start the epidemic with no initial debt:

- Prevents long debt crisis
- Allows more aggressive lockdowns
- Reduces fatalities from epidemic
- Economy can borrow to support consumption
# Epidemic Outcomes: Debt Matters

<table>
<thead>
<tr>
<th>Initial debt-to-output</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Health crisis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deceased (% Pop)</td>
<td>0.45</td>
<td>0.47</td>
<td>0.49</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td><strong>Economic Crisis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lockdown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length (months)</td>
<td>9.3</td>
<td>7.8</td>
<td>8.0</td>
<td>7.8</td>
<td>7.8</td>
<td>7.5</td>
</tr>
<tr>
<td>Intensity, max (%)</td>
<td>57</td>
<td>61</td>
<td>51</td>
<td>51</td>
<td>51</td>
<td>51</td>
</tr>
<tr>
<td>Output loss (%)</td>
<td>−25</td>
<td>−21</td>
<td>−18</td>
<td>−19</td>
<td>−20</td>
<td>−22</td>
</tr>
<tr>
<td><strong>Debt crisis</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Default</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length (months)</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>43</td>
<td>112</td>
<td>161</td>
</tr>
<tr>
<td>Intensity, max (%)</td>
<td>22</td>
<td>28</td>
<td>36</td>
<td>55</td>
<td>94</td>
<td>100</td>
</tr>
<tr>
<td><strong>Welfare loss</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Country CE (% output)</td>
<td>−76</td>
<td>−78</td>
<td>−81</td>
<td>−87</td>
<td>−87</td>
<td>−86</td>
</tr>
<tr>
<td>Lender (% output)</td>
<td>−0</td>
<td>−0.1</td>
<td>−0.2</td>
<td>−1.2</td>
<td>−2.0</td>
<td>−3.4</td>
</tr>
</tbody>
</table>

- Lower initial debt: Longer lockdowns, more lives saved, limited debt crises
- Higher initial debt: Longer and more intense defaults
Debt Relief Programs

▶ Main program: Default-free loan from financial assistance entity
  ▶ Long-term loan of 10% of output, structured as perpetuity
  ▶ Repayment starts 2 years later
  ▶ Evaluate epidemic outcomes for economies with varying initial debt

▶ Other programs
  ▶ Alternative loan structures: smaller, shorter-term, different timing
  ▶ Grants used for buybacks

▶ Compare value of programs with and without pandemic
Debt Relief: Main Program

Outcomes from 10% financial assistance long-term default-free loan (0 NPV)

<table>
<thead>
<tr>
<th>Initial debt-to-output</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Baseline)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welfare gains (% output)</td>
<td>4.3</td>
<td>6.6</td>
<td>9.4</td>
<td>8.8</td>
<td>8.6</td>
</tr>
<tr>
<td>Debt crisis: length reduction (months)</td>
<td>2</td>
<td>1</td>
<td>35</td>
<td>77</td>
<td>57</td>
</tr>
<tr>
<td>Health crisis: deaths prevented (% deaths)</td>
<td>4.6</td>
<td>5.5</td>
<td>1.3</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Welfare gains without pandemic (% output)</td>
<td>2.8</td>
<td>2.8</td>
<td>2.8</td>
<td>8.8</td>
<td>8.5</td>
</tr>
</tbody>
</table>

- Gains from program: better mitigation, preventing debt crises, relax fin. frictions
- Program generates 9.4% gain to country in baseline
- At low debt larger gains: use loan for better mitigation
- At high debt larger gains: use loan to prevent debt crises

Best to assist economies at the risk debt crisis: prevent debt crisis + saves lives
Debt Relief: Other Programs

Consider the baseline 30% of debt

<table>
<thead>
<tr>
<th>Programs</th>
<th>Main</th>
<th>Later-start</th>
<th>Short-term</th>
<th>Smaller</th>
<th>Grant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welfare gains (% output)</td>
<td>9.4</td>
<td>9.3</td>
<td>3.5</td>
<td>4.7</td>
<td>13.7</td>
</tr>
<tr>
<td>Debt: length reduction (months)</td>
<td>35</td>
<td>33</td>
<td>33</td>
<td>32</td>
<td>35</td>
</tr>
<tr>
<td>Health: deaths prevented (% deaths)</td>
<td>1.3</td>
<td>1.2</td>
<td>1.3</td>
<td>0.1</td>
<td>1.1</td>
</tr>
</tbody>
</table>

- Later-start: loan of 10% of output given at week 10, when lockdowns start
- Shorter-term: loan of 10% of output, pay over 1 year, 2 years after outbreak
- Smaller: loan of 5% output, pay as perpetuity
- Grant: Used for buybacks program
  financial assistance lose 10%, lenders gain 1%, positive social value

Longer-term loans do most of the work in helping with debt and health with higher welfare gains
Update SIR parameters to bring model deaths in line with data (Jan = first data point)

Preliminary: results on debt relief and role of debt are robust
Pandemic creates a huge challenge for emerging markets with default risk ⇒ health crisis + economic crisis + debt crisis

Lower debt burden prevents debt crisis and saves lives

Debt relief programs large social value
Appendix
Partial Default in the Data
Arellano et al. (2019)

Partial Default = \frac{Arrears}{Arrears + Debt Service}

> Arrears: sum of interest and principal in arrears for the total government debt public and publicly guaranteed
Partial Default: Frequency and Length

(a) Partial Default

(b) Default Episode Length
Partial Default and Debt

Table 1: Partial Default and Default Episodes in Percentages

<table>
<thead>
<tr>
<th>Partial Default Frequency</th>
<th>&gt; 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>35</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Default Episodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Episode length (years)</td>
</tr>
<tr>
<td>Fraction of short episodes (≤ 2 years)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Debt During Episode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before episode</td>
</tr>
<tr>
<td>Beginning of episode</td>
</tr>
<tr>
<td>Middle of episode</td>
</tr>
<tr>
<td>After episode</td>
</tr>
</tbody>
</table>
Baseline economy paths: Long paths

(a) Lockdown Intensity

(b) Consumption and Output

(c) Spread

(d) Partial Default

(e) Debt
Policy rules: Bond price

- More infected and susceptible population lower bond prices
- Epidemic lowers debt repayment prospects and prevents use of foreign borrowing
Exogenous lockdowns

Experiment:
- start with steady state debt level
- lockdown starts 1 month after outbreak
- lockdown at 50% for 4 months

▶ Reduces fatalities from 1% to 0.7% (half of optimal)
▶ Debt crisis worse