COVID-19 Vaccination and Financial Frictions

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Introduction

Three features of COVID in many developing countries

- Slow vaccination
- Financial market frictions limit fiscal support and mitigation efforts
- Robust international financial assistance to manage the epidemic

We study the interaction between these features by asking:

- Do financial frictions make an epidemic more costly?
- Is vaccine scarcity especially detrimental for developing countries?
- Does international financial assistance increase vaccinations?

What we find

Do financial frictions make an epidemic more costly? Yes!

- Financial market access helps with epidemic management
- Supports consumption while social distancing and supports vaccine purchases

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Is vaccine scarcity especially detrimental for developing countries? Yes!

- Financial market access and vaccinations are **complements**
- Financial resources reduce early infections $\rightarrow$ more people in need of vaccine
- Developing countries do not have the leisure of time if tight financial frictions

Financial assistance loans buy time until vaccination is possible

Framework

- Small open economy with epidemiological and economic blocs
  - Add vaccinations to Arellano, Bai, and Mihalache (2020)
- Epidemic follows SIR model with multiple waves and mitigation:
  - Social distancing temporarily reduces infections
  - Vaccination permanently reduce infections
- Economic side
  - International borrowing subject to financial frictions
  - Preferences over consumption and life
  - Social distancing reduces output; vaccine purchases reduce domestic resources

Epidemic Dynamics with Vaccination

- Epidemic: Population transits from susceptible to infected or recovered

$$\mu^S \to \mu^I \to [\mu^R \text{ or } \mu^D], \qquad \text{or,} \qquad \mu^S \to \mu^R \text{ with vaccination}$$

- New infections from the interaction of infected (μ_t^I) and susceptible (μ_t^S)

$$\mu_t^n = \tilde{\mathcal{R}}_0 \left[(1-\theta L_t)\mu_t^I\right] \left[(1-\theta L_t)\mu_t^S\right]$$

- Social distancing (L_t) reduce temporarily infections

- Susceptible might become infected or receive a vaccine (X_t):

$$\mu_{t+1}^S = \mu_t^S - \mu_t^n - X_t$$

- Vaccinated gain immunity and become recovered— infections reduced permanently

- Deceased depend on infections subject to health care constraints

$$\mu_{t+1}^D = \mu_t^D + \pi_D(\mu_t^I)\mu_t^I$$

Preferences, Technology, and Debt

- Preferences over consumption c_t and life — ϕ_t^D are fatalities, χ value of life

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

- Output depends on social distancing L_t and population N_t: $\quad Y_t = [N_t(1 - L_t)]^\alpha$
- Use international borrowing B_{t+1} to support consumption and vaccine purchases

$$N_t c_t + p X_t \leq Y_t - (1 + r) B_t + B_{t+1}.$$

- Borrowing and *vaccine capacity* subject to constraints: $\quad B_{t+1} \leq \overline{B}, \quad X_t \leq \overline{X}_t$
  - Social distancing L_t: depresses output
  - Vaccines X_t: in limited supply and cost p

Dynamic Problem: Baseline

- Unexpected epidemic outbreak at time $t = 0$, March 2020, the "first wave"
  - Initial infections $\mu_0^I > 0$, initial stock of debt B_0
  - Vaccines become available in one year with limited quantities
- Planner makes all choices: social distancing (L_t), vaccine purchases (X_t), and borrowing (B_{t+1})
  - Maximize objective function subject to all constraints
- Unexpected "second wave" of infection one year in, in March 2021
  - Increase in infectiousness ($\mathcal{R}_0$) from new variant

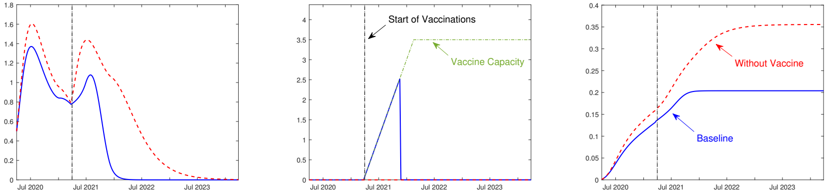
Parameters

- Weekly model
- **Vaccination Capacity:**
  $\overline{X} = 3.5\%$ peak weekly vaccinations in US

$$\overline{X}_t = \begin{cases} 0, & \text{unavailable, if } t < 52 \\ \dfrac{t-52}{52}\overline{X}, & \text{ramp up, if } t \in [52, 103] \\ \overline{X}, & \text{peak capacity reached, if } t \geq 104 \end{cases}$$

- **Vaccine Price:**
  \$40 per vaccine course, giving $p = 0.2$ of weekly income for Mexico
- Other parameters from literature and Arellano, Bai, and Mihalache (2020) from Latin America calibration: SIR probabilities, time-varying $\mathcal{R}_0$ with two waves, technology and preferences, financial markets, $\beta(1+r) < 1$, initial debt to output and borrowing limit 60%

Baseline Results



Infected, μ_I Vaccinations, X Deceased, μ_D

Vaccines save lives but not fully used

Baseline Outcomes

Health	
Vaccinations	45
Fatalities	0.2
Mitigation Costs (% output)	
Social Distancing	15
Vaccine Expenditure	0.2
Welfare Cost of Pandemic	
Consumption Equivalent	-0.70

- Sizable welfare cost of epidemic
- Large number of fatalities (similar to fatalities for Mexico)
    - But lower than without vaccines (40% less)
- Social distancing cost significant, vaccine expenditure very minor

Vaccine Scenarios

- Quantity scenarios: Quick full capacity immediately after a year; Slow: Ramp-up takes 2 years
- Price scenarios: Low–0.035 relative to weekly income (U.S.); High–7 (Burundi)

Quantity ramp up	Quick	Baseline	Slow
Vaccinations	56	45	37
Fatalities	0.16	0.20	0.22
Social Distance Cost	13	15	16
Welfare (CE)	-0.59	-0.70	-0.74
Price	Low	Baseline	High
Vaccinations	60	45	18
Fatalities	0.20	0.20	0.24
Social Distance Cost	15	15	14
Welfare (CE)	-0.70	-0.70	-0.76

- Deploying vaccines *fast* is more important than pricing, except at very low income levels

Financial Markets and Vaccines

- We compare baseline to the reference case of *Perfect Financial Markets*:
- Choices subject only to a lifetime budget constraint.

$$\sum_{t=0}^{\infty} \frac{1}{(1+r)^t}(N_t c_t + pX_t) \leq -(1+r)B_0 + \sum_{t=0}^{\infty} \frac{1}{(1+r)^t}[N_t(1-L_t)]^{\alpha}$$

- Consumption need not track income

Financial Markets and Vaccines

	Baseline	Perfect
Health		
Vaccinations	45	65
Fatalities	0.20	0.05
Mitigation Costs (% output)		
Social Distancing	15	30
Vaccine Expenditure	0.2	0.3
Welfare Cost of Pandemic		
Consumption Equivalent	−0.70	−0.38

- Better financial markets are *complementary* with vaccine use
- In expectation of vaccine ramp up, aggressive early social distancing.
- Epidemic less costly with perfect financial markets

International Financial Assistance

- Evaluate long-term loans where international assistance breaks even

	Baseline	Early Loan	Late Loan
Health			
Vaccinations	45	50	44
Fatalities	0.20	0.17	0.19
Mitigation Costs (% output)			
Social Distancing	15	19	16
Vaccine Expenditure	0.17	0.19	0.17
Welfare Cost of Pandemic			
Consumption Equivalent	-0.70	-0.47	-0.37

- Early loan (first wave): intensive early social distancing, prevents first wave infections
- Late loan (second wave): supports social distancing during the second wave, helps smooth consumption.

Conclusions

- Vaccines are complementary to better financial market conditions
  - International financial assistance particularly useful with this complementarity
- Vaccine prices are low compared to social value, binding constraint is capacity, unless very poor