COVID-19 Vaccination in Emerging Markets

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Introduction

- We study vaccination and international financial assistance to emerging markets, building on ABM 2020 *"Deadly Debt Crises"*
- Vaccines useful but quantities significantly constrained in emerging markets
- Financial market access is essential for managing the epidemic
  - Supports social distancing before vaccine availability
  - Supports vaccine purchases, when eventually accessible
- Financial assistance loans increase vaccination and prevent fatalities

Outline

- Small, open economy with epidemic dynamics (SIR) and mitigation policies: social distancing and vaccination
- Unexpected outbreak, unexpected resurgence of infections (“second wave”)
- Study economic and epidemic outcomes under
  - Timing and quantity constraint on vaccine purchases
  - Varying financial market conditions
  - Timing and size of international financial assistance

SIR Dynamics with Vaccination

New infections arise from the interaction of the current stock of infected (μ_t^I) and susceptible (μ_t^S), subject to social distancing measures (L_t):

$$\mu_t^n = \pi_n \left[(1 - \theta L_t)\mu_t^I\right] \left[(1 - \theta L_t)\mu_t^S\right]$$

The susceptible might become infected or receive a vaccine (X_t):

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

A share of $1 - \pi_I$ of the currently infected recover or die:

$$\mu_{t+1}^I = (1 - \pi_I)\mu_t^I + \mu_t^n$$

$$\mu_{t+1}^R = \mu_t^R + X_t + \left[1 - \pi_I - \pi_D(\mu_t^I)\right] \mu_t^I$$

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

Dynamic Problem: Constraints

Resource constraint:

$$N_t c_t + pX_t \leq [N_t(1 - L_t)]^{\alpha} - (1+r)B_t + B_{t+1}.$$

Borrowing and *vaccine capacity* constraints:

$$B_{t+1} \leq \overline{B} \qquad\qquad X_t \leq \overline{X}_t,$$

- Social distancing L_t: depresses output but reduces new infections
- Vaccines X_t: reduce mass of susceptibles but in limited supply and cost p
- Borrowing B_{t+1}: supports consumption and vaccine purchases

Dynamic Problem: Objective

The objective function depends on consumption and fatalities,

$$\sum_{t=0}^{\infty} \beta^t \left[u(c_t) - \chi \Delta \mu_t^D \right],$$

Choose social distancing (L_t), vaccine purchases (X_t), and borrowing (B_{t+1}) to maximize the objective subject to

- SIR dynamics
- a sequence of budget constraints and borrowing limits
- a vaccine capacity schedule $\{\overline{X}_t\}$

The Timing of Events

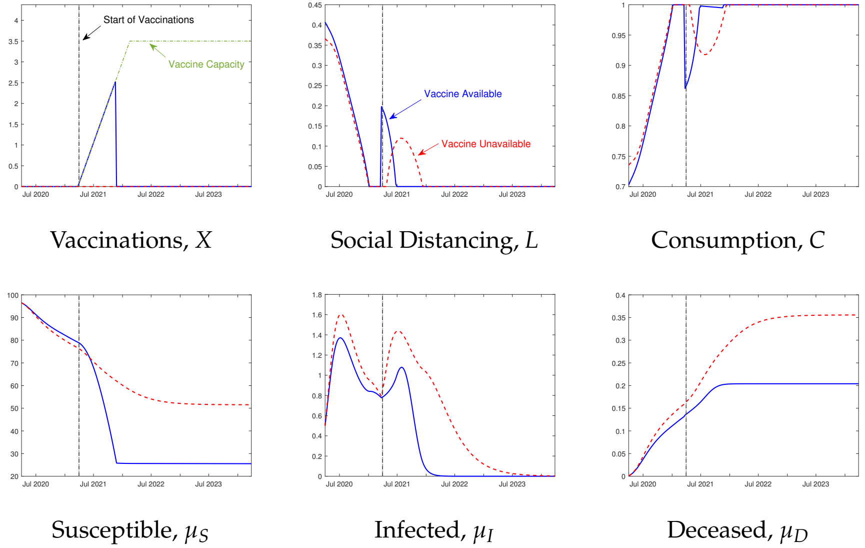
1. Unexpected epidemic outbreak at time $t = 0$, March 2020, the “first wave”
   - Initial infections $\mu_0^I > 0$, initial stock of debt B_0
   - Initially high and decaying infectiousness (time-varying $\mathcal{R}_0$), like ABM 2020
   - Vaccines become available in one year, with capacity ramping up and plateauing
2. Unexpected “second wave” of infection one year in, in March 2021
   - Increase in infectiousness ($\mathcal{R}_0$) from new variant

Parameters

- Weekly. Following ABM 2020, fitting Latin America data from 2020: SIR, time-varying $\mathcal{R}_0$, technology and preferences, financial markets, $\beta(1+r) < 1$, initial debt to output and borrowing limit 60%
- **Vaccination Capacity:**
  $\overline{X} = 3.5\%$ peak weekly vaccinations in US

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

- **Vaccine Price:**
  \$40 per vaccine course, giving $p = 0.2$ for Mexico



Vaccines save lives, support sharper and shorter social distancing, but not fully used (epidemic winds down before vaccine capacity is maxed out).

Baseline Outcomes

Health	
Vaccinations	45
Fatalities	0.20
Mitigation Costs (% output)	
Social Distancing	15
Vaccine Expenditure	0.2
Welfare Cost of Pandemic	
Consumption Equivalent	-0.70

For reference, in Mexico 0.22% fatalities to date.

Vaccine Scenarios

Quantity ramp up	Quick	Baseline	Slow
Vaccinations	56	44	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	44	18
Fatalities	0.20	0.20	0.24
Social Distance Cost	15	15	14
Welfare (CE)	-0.70	-0.70	-0.76

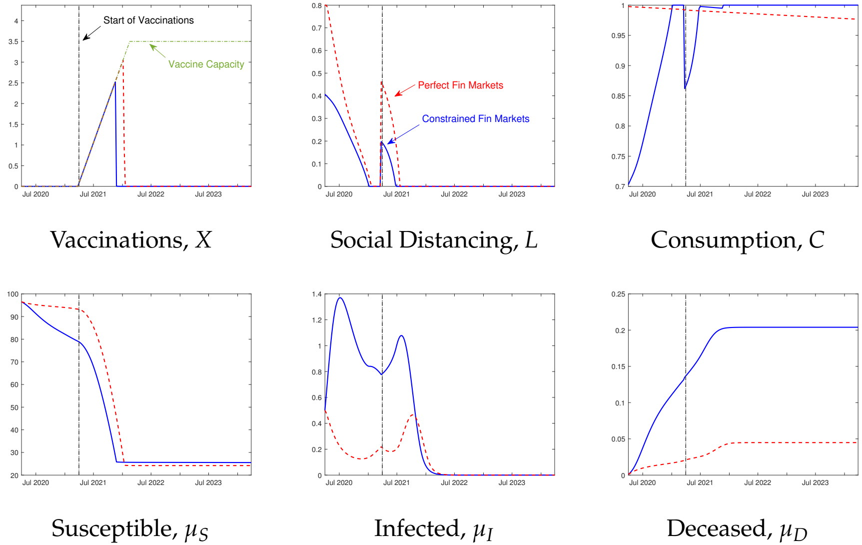
Deploying vaccines *fast* is more important than pricing, except at very low income levels.

Financial Markets and Vaccines

- We compare baseline to the reference case of *Perfect Financial Markets*:
- Choices subject only to a *lifetime* budget constraint. Consumption need not track income

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

- With perfect financial markets, vaccine are used more extensively, *better financial markets are complementary to vaccine use.*



Perfect financial markets save lives, through more aggressive social distancing and increased vaccine purchases, while maintaining smooth consumption.

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.

International Financial Assistance

- Can international financial assistance improve outcomes?
  - Through complementarity of financial markets and vaccine
- Evaluate long-term loan M. International assistance breaks even

$$N_t c_t + pX_t \leq [N_t(1 - L_t)]^\alpha - (1+r)B_t + B_{t+1} + \mathbb{1}_{\{t=\tau\}}M - \mathbb{1}_{\{t>\tau\}}rM$$

- Country adjusts financial position B, to optimizing timing of funds
- Consider two programs with $M = 7\%$ of annual output
  - *Early*, $\tau = 0$, during first wave
  - *Late*, $\tau = 52$, during the second wave

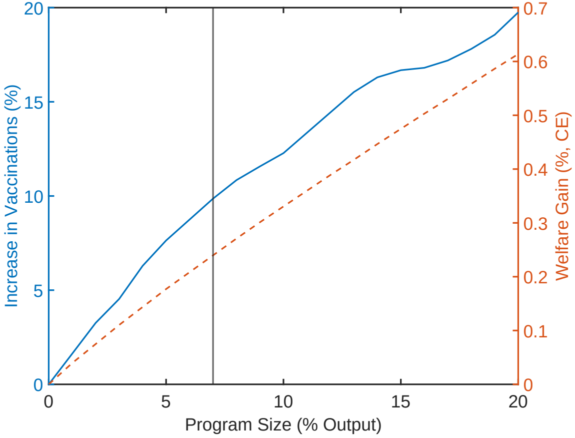
International Financial Assistance

	Baseline	Early Loan	Late Loan
Health			
Vaccinations	44	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: intensive early social distancing, prevents first wave infections.

Late loan: supports social distancing during the second wave, helps smooth consumption.

International Financial Assistance

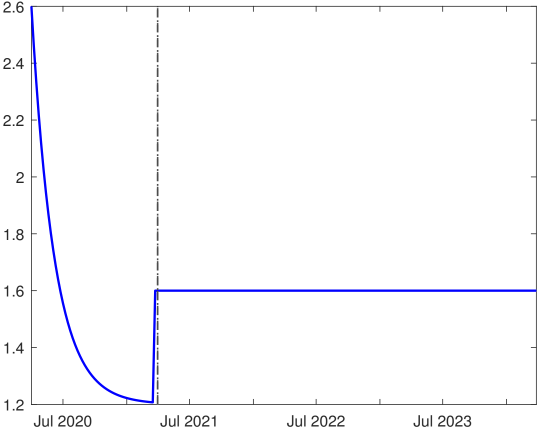


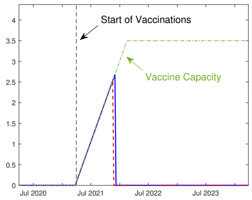
- The bigger, the better
- Large welfare gains from
  - expanding vaccinations
  - preventing deaths
  - better consumption smoothing

Conclusions

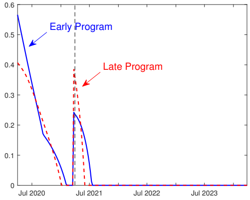
- Vaccines: *effective* at preventing fatalities and hastening the end of epidemic
- Vaccine prices are low compared to their social value, the binding constraint in emerging markets is *vaccine capacity*. Unless exceptionally poor
- International financial assistance was particularly useful
  - Vaccines are complementary to better financial market conditions

$\mathcal{R}_0$

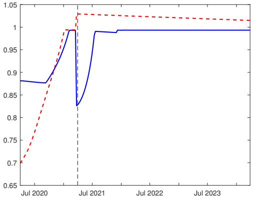




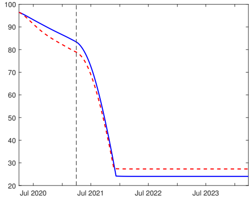
Vaccinations, X



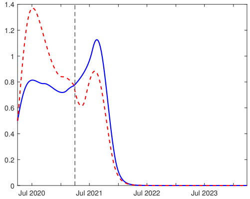
Social Distancing, L



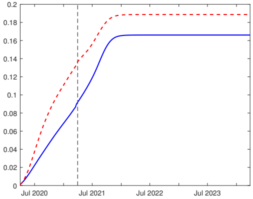
Consumption, C



Susceptible, μ_S



Infected, μ_I



Deceased, μ_D

Late loan provides insurance for unexpected second wave of infections.