The Macroeconomics of Epidemics

Martin Eichenbaum, Sergio Rebelo, and Mathias Trabandt

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Introduction

- Epidemiology models widely used to predict course of epidemic.
- While very useful, they don't allow for the two-way interaction between economic decisions and rates of infection.
  - Epidemic causes recession as people shop and work less to reduce chances of infection (Chetty et al. '20, Goolsbee-Syverson '20).
  - Number of people that work or go shopping influences rate at which infections spread.
- How important is the two-way interaction? What macroeconomic policies should the government pursue in an epidemic?

Eichenbaum, Rebelo and Trabandt (ERT) model

- Point of departure: SIR model by Kermack and McKendrick (1927).
  - Exogenous transition probabilities between health states.

- Continuum of agents with measure one.

- The population is divided into four groups
  - Fraction S_t: susceptible (not yet been exposed to disease);
  - Fraction I_t: infected (contracted disease);
  - Fraction R_t: recovered (survived disease and acquired immunity);
  - Fraction D_t: deceased (died from disease).

ERT model

- Prior to epidemic, everyone identical and maximize:

$$U = \sum_{t=0}^{\infty} \beta^t \left\{ \ln c_t - \frac{\theta}{2} n_t^2 \right\}$$

- Household budget constraint: $(1 + \mu_t) c_t = w_t n_t + transfers_t$.
- μ_t: tax (Pigouvian) on c_t; proxy for containment measures that reduce social interactions.
  - We refer to μ_t as the containment rate.
- Continuum of competitive representative firms: $C_t = A N_t$.

Population dynamics

- Newly infected people given by transmission function:

$$T_t = \pi_1 (S_t C_t^S)(I_t C_t^I) + \pi_2 (S_t N_t^S)(I_t N_t^I) + \pi_3 S_t I_t.$$

- Number of susceptible people at time $t+1$:

$$S_{t+1} = S_t - T_t.$$

- Number of infected people at time $t+1$:

$$I_{t+1} = I_t + T_t - (\pi_r + \pi_d) I_t.$$

  - π_r = recovery rate. π_d = mortality rate.

Population dynamics

- Number of recovered people at time $t+1$:

$$R_{t+1} = R_t + \pi_r I_t.$$

- Number of deceased people at time $t+1$:

$$D_{t+1} = D_t + \pi_d I_t.$$

Susceptible, infected and recovered people

- Utility susceptibles: $U_t^s = u(c_t^s, n_t^s) + \beta \left[(1 - \tau_t) U_{t+1}^s + \tau_t U_{t+1}^i \right]$
  - Infection prob.: $\tau_t = \pi_1 c_t^s (I_t C_t^I) + \pi_2 n_t^s (I_t N_t^I) + \pi_3 I_t$
- Utility infected: $U_t^i = u(c_t^i, n_t^i) + \beta \left[(1 - \pi_r - \pi_d) U_{t+1}^i + \pi_r U_{t+1}^r \right]$
- Utility recovered: $U_t^r = u(c_t^r, n_t^r) + \beta U_{t+1}^r$
- Budget constraints: $(1 + \mu_t) c_t^j = w_t \phi^j n_t^j + transfers_t, j = s, i, r$

Parameter values

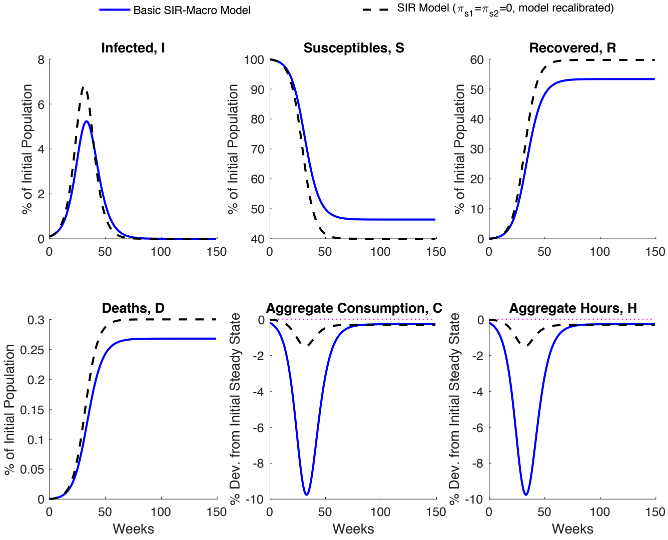
- Weekly parameterization.
- Mortality rate = 0.5 percent.
  - Weighted average of mortality rates by age in South Korea computed using U.S. population weights for people younger than 70 years old.
- Choose A and θ to match hours worked and income before epidemic.
- $\beta = 0.96^{1/52}$: value of life 9.3 million 2019 dollars pre-epidemic.
  - Value used by U.S. government agencies.
  - Discuss robustness for value of life using additive constant as in Hall and Jones (2007) and estimates in Hall, Jones and Klenow (2020).

Parameter values: transmission function

- Based on Ferguson et al. (2006), BLS 2018 ATUS and Lee (2009) choose π_1, π_2 and π_3 so that at the beginning of the epidemic:
  - 1/6 of new infections due to consumption.
  - 1/6 of new infections due to work.

    Thus, remaining 2/3 of new infections due to general infections.
  - 60 percent of population either recovers or dies from infection in simple SIR model (Merkel scenario).
- Discuss robustness w.r.t. π_1, π_2 and π_3.

Figure 1: Basic SIR-Macro Model vs. SIR Model



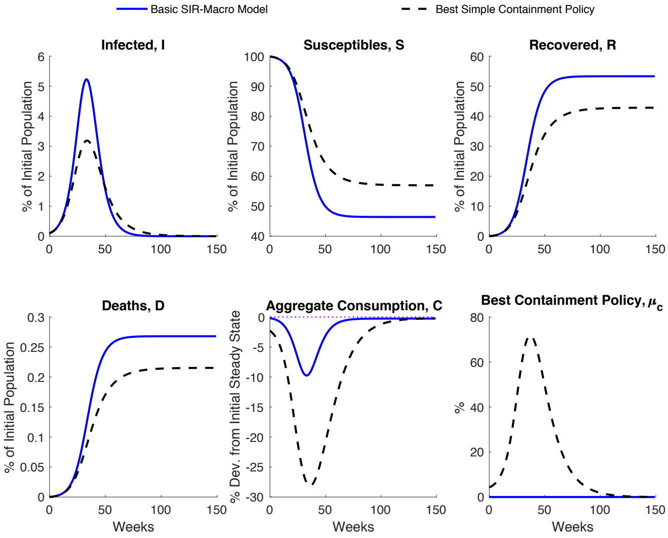
ERT model

- In our model, epidemic has both aggregate demand and supply effects.
- Supply effect: epidemic exposes people who are working to the virus.
  - People react to that risk by reducing their labor supply.
- Demand effect: epidemic exposes people who are purchasing consumption goods to the virus.
  - People react to that risk by reducing their consumption.
- Supply and demand effects work together to generate a large, persistent recession.

Simple containment

- Infection externality: people infected with virus do not fully internalize effect of their consumption and work decisions on virus spread.
- What policies should gov't pursue to deal with infection externality?
- "Simple containment":
  - Optimal path μ_t that maximizes welfare $U_0 = S_0 U_0^s + I_0 U_0^i + R_0 U_0^r$.
  - Best simple containment implies trade off between economic activity and health outcomes: recession exacerbated – death toll reduced.

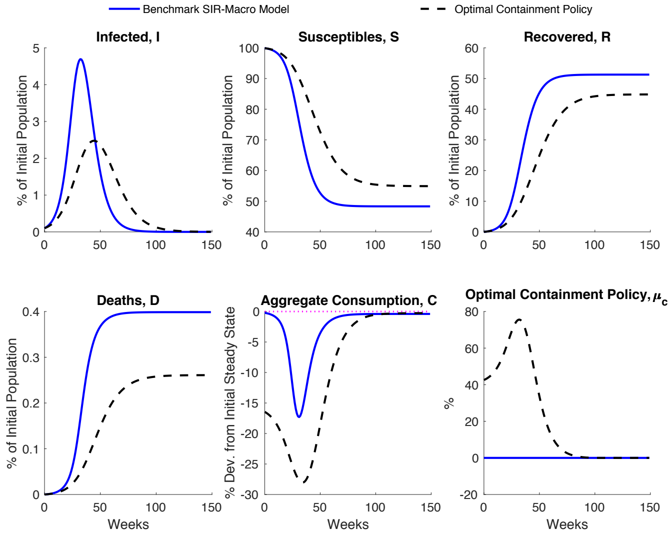
Figure 3: Basic SIR-Macro Model With and Without Containment



Benchmark ERT model

- Basic ERT model plus the following three extensions:
  - Medical preparedness: mortality rate increases as number of infections rises because efficacy of healthcare system deteriorates.
  - Treatment: with probability δ_c per period an effective treatment that cures infected people is discovered.
  - Vaccine: with probability δ_v per period an effective vaccine is discovered.

Figure 7: Benchmark SIR-Macro Model (Vaccines, Treatment, Med. Preparedness)



Smart containment

- How well can a social planner do if she can treat people differently according to their health status?
- Key result: Smart containment much better than simple containment.
  - No tradeoff between economic activity and health outcomes – much milder recession *and* far fewer deaths than in competitive equilibrium.
- Implementing smart containment requires policy makers to know the health status of different individuals.

The Macroeconomics of Testing and Quarantines

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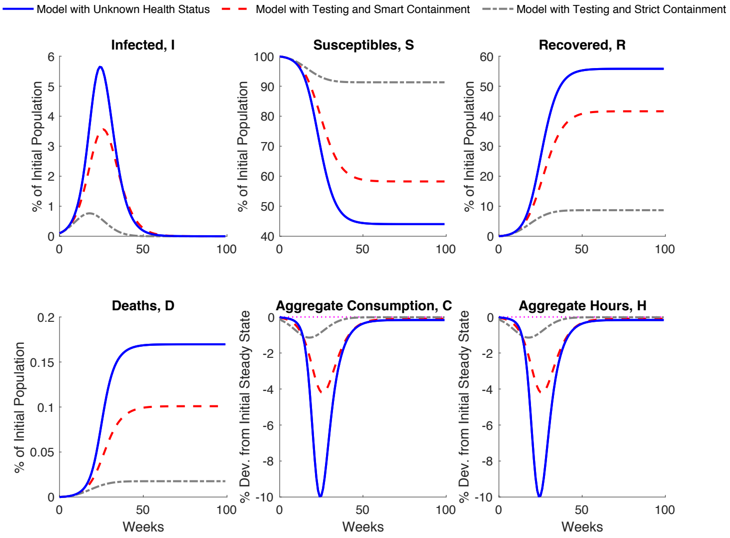
- Study impact of testing with and without quarantining infected people in a model in which people are uncertain about their health status.
- Result 1: testing without quarantines can worsen the economic *and* health repercussions of an epidemic.
- Result 2: testing with quarantines has very large social benefits:
  - Amelioration of tradeoff between economic activity *and* health outcomes associated with lockdowns/simple containment.
- Result 3: with temporary immunity after infection, testing and quarantining has huge social benefits.

Figure 7: Model with Testing and Strict Containment



Robustness

- Our conclusions are robust to allowing for capital accumulation and nominal rigidities.
- See Eichenbaum, Rebelo and Trabandt, 2020, Epidemics in the Neoclassical and New Keynesian Models.

Thank you for your attention.

*Matlab and Matlab/Dynare replication codes available at:
https://sites.google.com/site/mathiastrabandt/home/research