# The Macroeconomics of Testing and Quarantines

Based on joint work with Sergio Rebelo, and Mathias Trabandt

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# Introduction

- The initial response of most governments to the COVID-19 epidemic was to implement simple containment measures.
- These policies imply a sharp, negative tradeoff between the level of economic activity and the health consequences of an epidemic.
- Smart containment policies that combine testing and quarantining dramatically improve the tradeoff between economic activity and health outcomes.

# Intro...

- Epidemiology models are widely used to predict the course of the epidemic.
- While very useful, they don't allow for interaction between economic decisions and rates of infection.
  - The epidemic causes a recession as people consume and work less to reduce the chance of getting infected.
  - The amount that people work and consumer influences the rate at which infections spread.
- Absence of these interactions limits their usefulness for forecasting and policy analysis.
- Crisis has created an explosion of work combining economics and epidemiology.

# Recessionary effects of an epidemic

- Eichenbaum, Trabandt and Rebelo (2020a): 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.
- Recession would occur even if the government didn't institute any containment policies.

# An important role for the government

- Infection externality: people infected with the virus don't fully internalize the effect of their consumption and work decisions on spread of the virus.
- What policies should gov't pursue to deal with infection externality?
- Simple containment policies (lockdowns), make the recession worse but raise welfare by reducing death toll caused by epidemic.
- Smart containment: treat people differently based on their health status (Eichenbaum et. al.), tracing (Alvarez et. al.) and age (Acemoglu et.al.)

# SIR-macro model

- Point of departure: SIR model by Kermack and McKendrick (1927).
  - Exogenous transition probabilities between health states.
- Population is divided into four groups
  - Susceptible (not yet been exposed to disease);
  - Infected (contracted disease);
  - Recovered (survived disease and acquired immunity);
  - Deceased (died from disease).

# Population dynamics

- People interact in goods and labor markets.
- New infections arise from three types of social interactions
  - Non-economic social interactions
  - Consumption-based activities
  - Work-related activities.
- Susceptible people can become infected.
- Infected people can recover or die.
- For now we assume recovered people can't become infected again.

# Model elements

- Government can impose various forms of containment
- Simple containment
  - 'Tax' consumption' activities in ways that doesn't differentiate people on basis of their health status.
- See paper for details of how we parameterize model.
  - Infection probabilities, risk aversion, constrains on the medical system, possible future arrival of vaccinations, treatments...

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

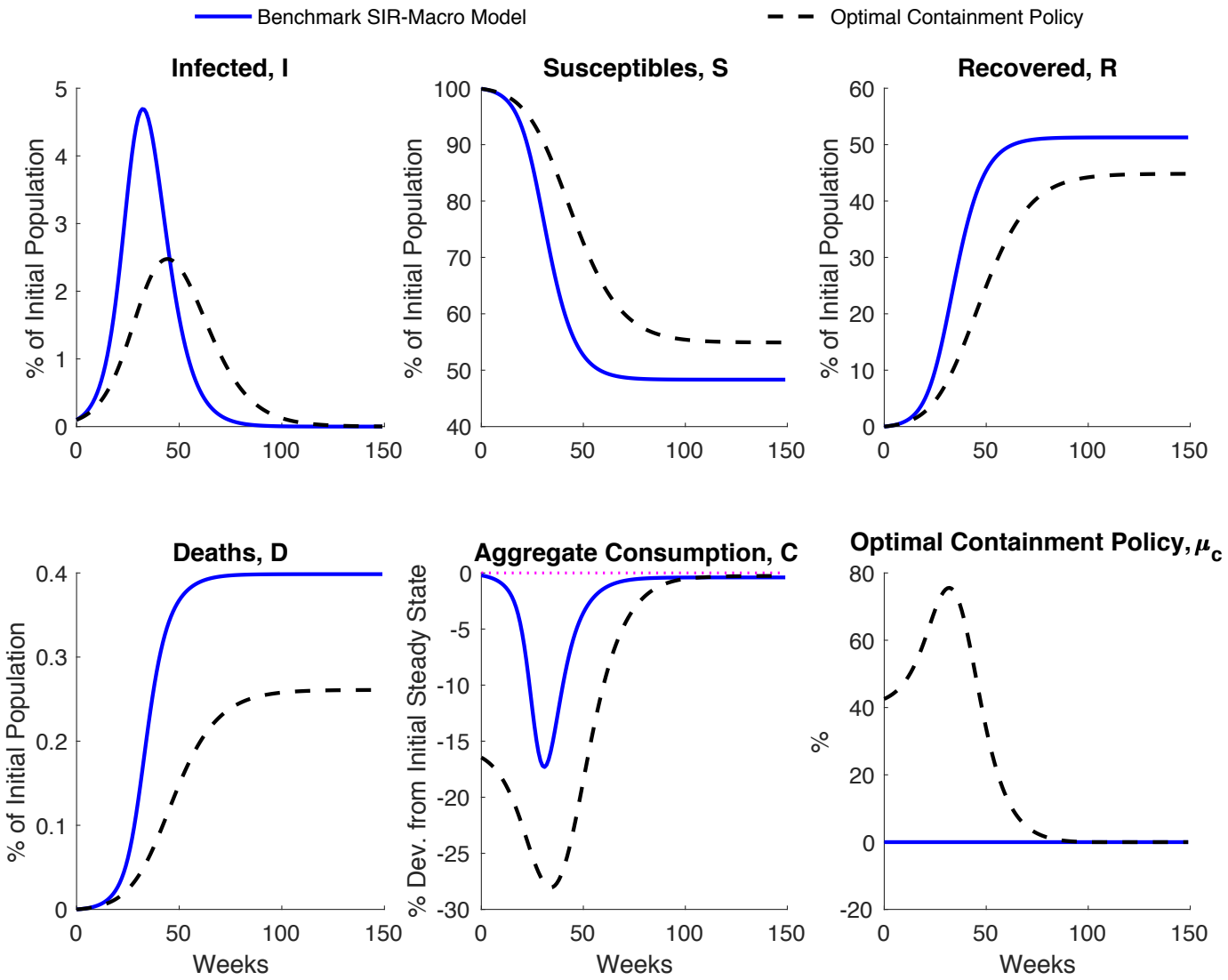
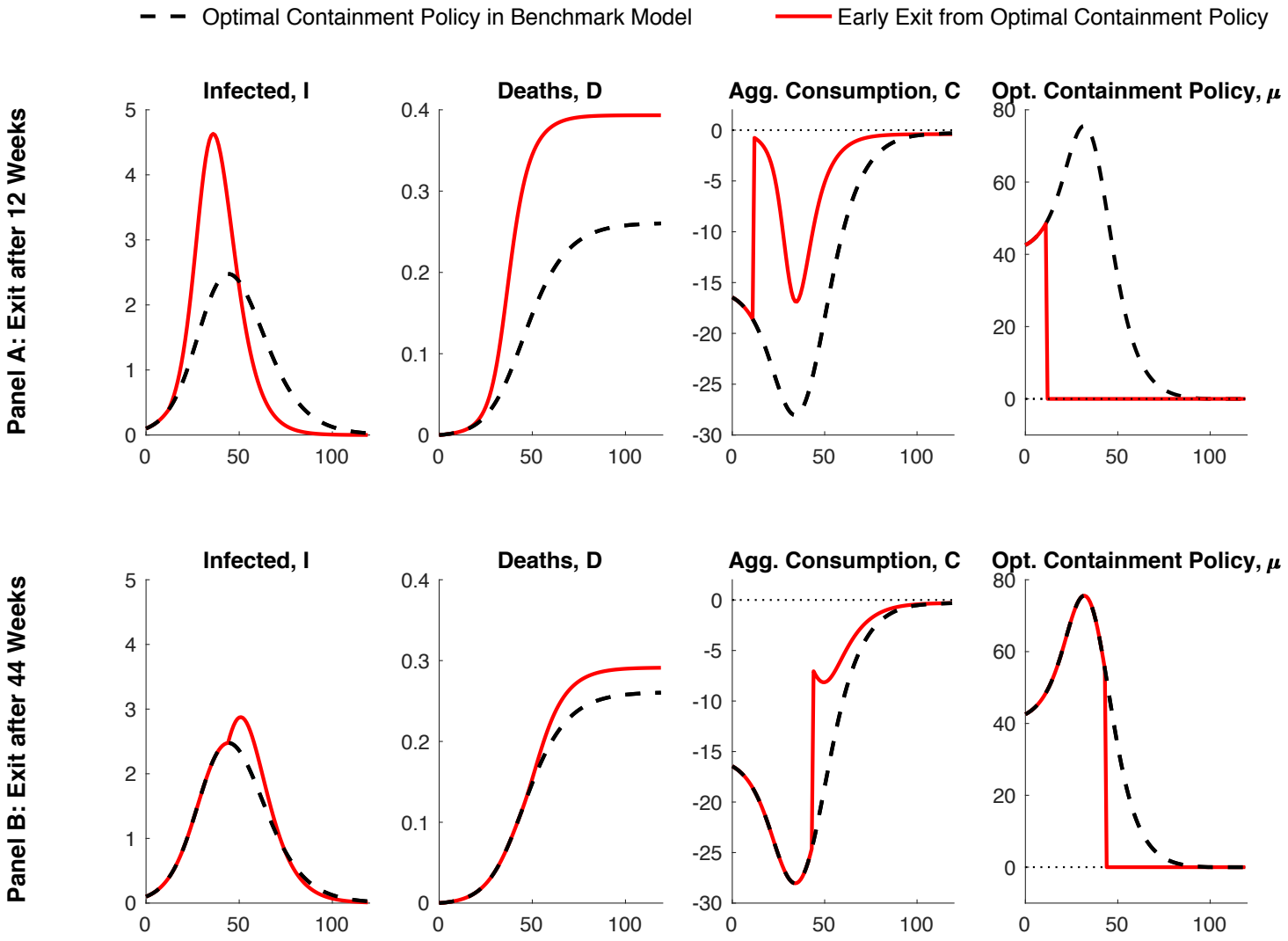


Figure 8: Benchmark SIR-Macro Model (Vaccines, Treatment, Med. Preparedness)




Notes: x-axis in weeks; infected and deaths in % of ini. population; consumption in % dev. from ini. steady state; opt. containment policy in %.

# Testing and Quarantines

- Much of existing economics literature on epidemics assumes people know their current health status.
- To extent that individual's health status is public information, there is no role for testing.
- Extend our framework to suppose people don't know their true health status unless they're tested.
- Analyze effects of testing and quarantining.

# Testing and Quarantines

- Two reasons to engage in testing.
  1. Obtain better estimates of how many people have been exposed to the virus and refine estimates of key parameters in epidemiology models.
  2. Reduce transmission rates by quarantining infected people.
- Testing alone doesn't resolve key market failure associated with epidemics.

# Testing without quarantines

- Worsens economic and health repercussions of an epidemic.
  - People who are unsure about their health status are likely to reduce their economic activity to lower the risk of becoming infected.
  - But if they get tested and find they're infected, they'll reduce their economic activity by less.
  - With more infected people shopping and working, social interactions become more risky for non-infected people who respond by cutting back on their economic activity.
  - Net result: deeper recession and more deaths.

# Testing with quarantine

- Simple containment:
  - Infected people don't work, receive consumption but aren't isolated from non-economic social interactions
- Strict containment:
  - Infected people are also isolated from non-economic social interactions

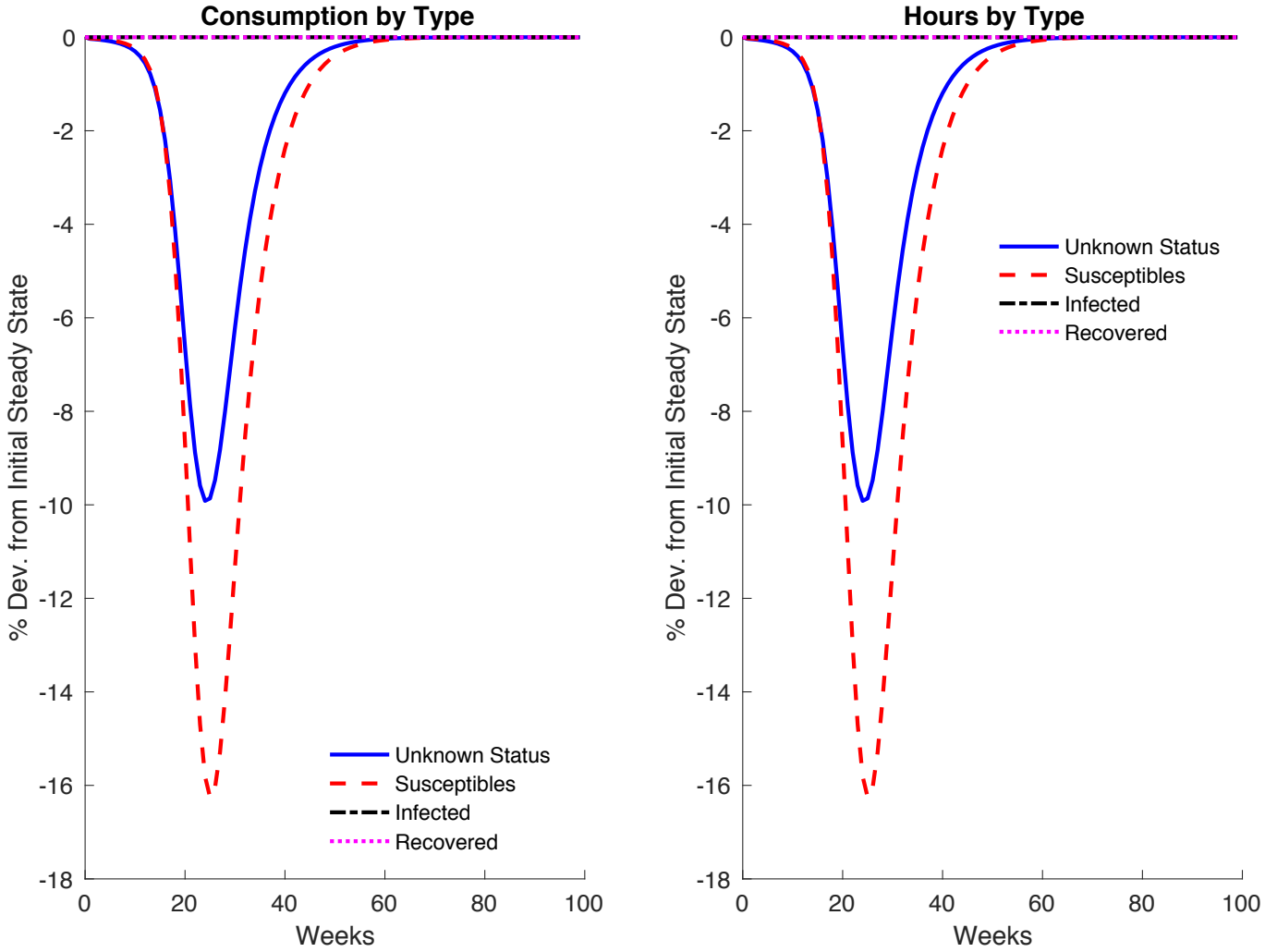
# Testing with quarantine

- Both types of quarantines dramatically improve tradeoff between economic activity and health outcomes.
  - Reduces amount of infections induced by economic activity.
  - Reduces infection risk relative to the competitive equilibrium.
  - So it leads to more hours worked and consumption by two groups of people
    - those who are uncertain about their health status.
    - those who know they are susceptible to infection

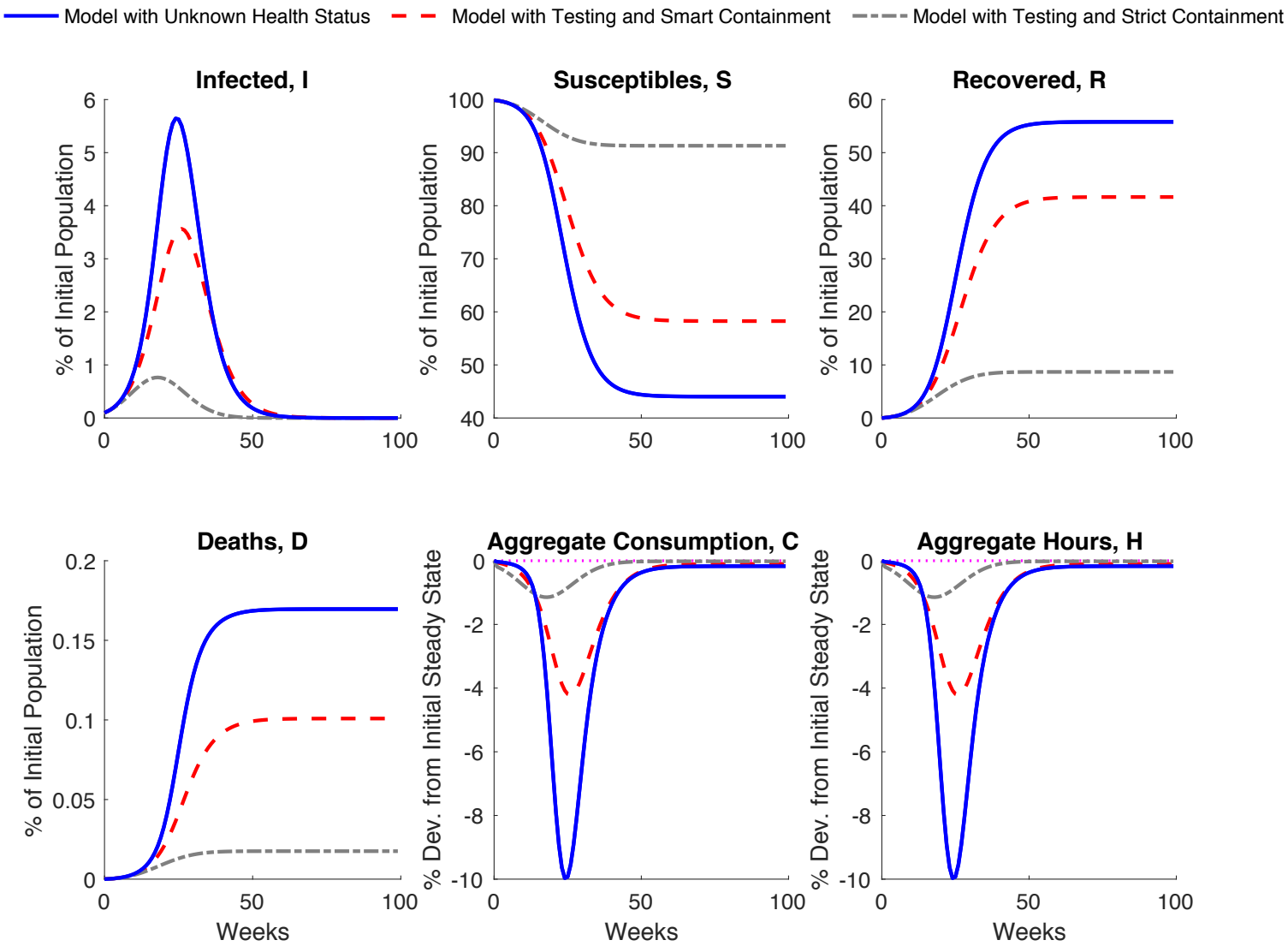
# Simplifications

- Tests are perfectly accurate and can determine whether a person is susceptible, infected or recovered.
- Two types of people
  - People outside the testing pool who have not yet been tested.
  - People inside the testing pool who get tested every period until they recover or die.
- In every period the government tests $\alpha$ percent of the population that has not yet been tested.

Figure 2: Model with Unknown and Known Health Status



# Figure 7: Model with Testing and Strict Containment



# Testing under smart containment

- By the end of the first year 38 of the population is tested every week.
- At the end of the 1st year, the population reaches herd immunity so testing can stop.
- See paper for details on how results depend on $\alpha$.
  - Rise in $\alpha$ from 0 to 2 percent cuts the peak-to-trough change in consumption in half.
  - Further rises in $\alpha$ continue to reduce the economic costs of the epidemic but at a slower rate, with very small reductions beyond $\alpha = 0.06$.
  - Similar but less stark pattern emerges regarding death toll from the epidemic.

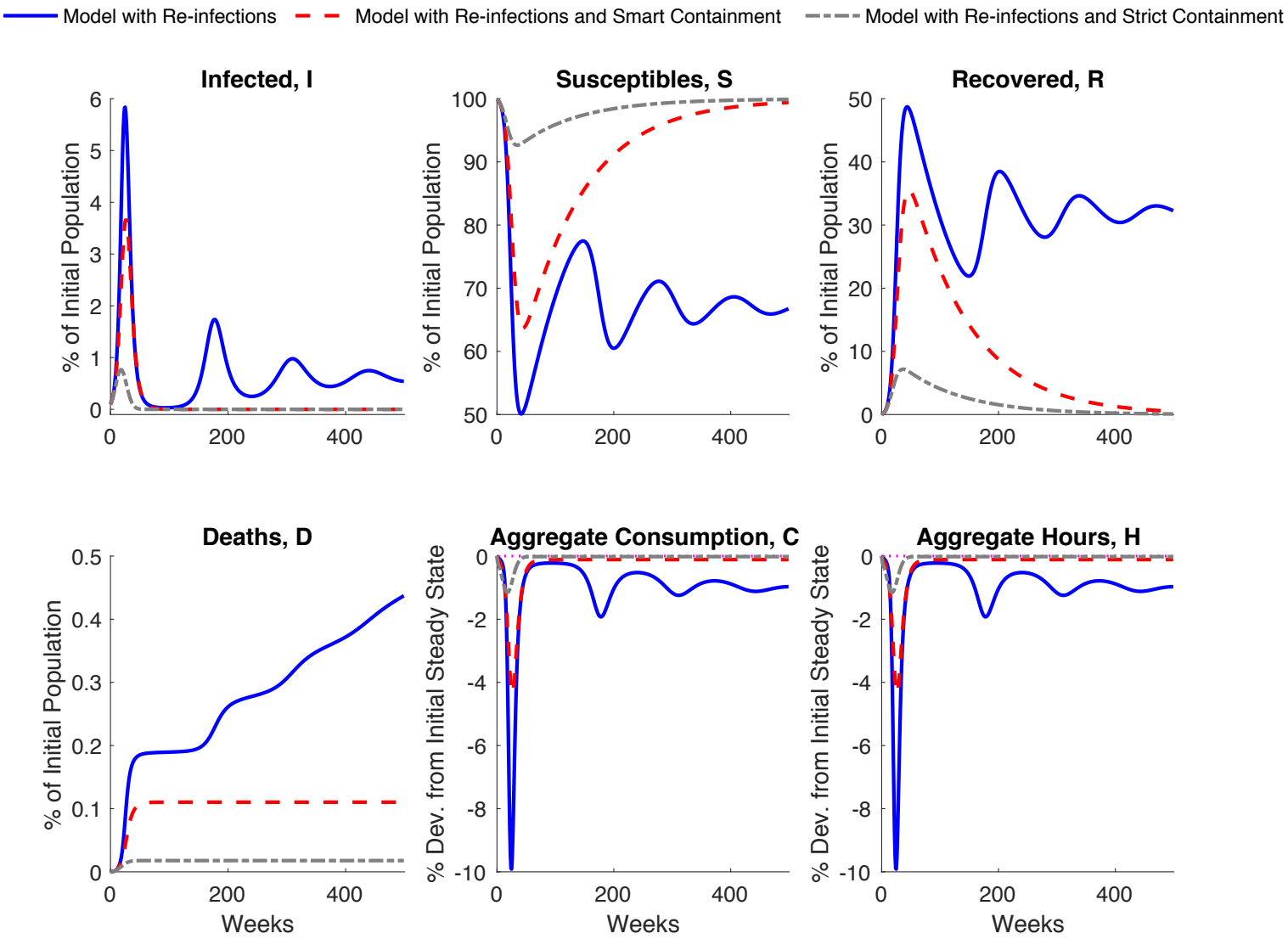
# Testing under strict containment

- $\alpha = 0.02 \Rightarrow$ by end of 1st year, 59 percent of population is tested every week. By the end of the 2nd year, this number is 80 percent.
- Many fewer people get infected and recover so many more people in the testing pool continue to be tested.
- The economy never reaches steady-state herd immunity.
  - Testing and quarantining policies have to be deployed on a permanent basis until effective treatments or vaccines are developed.

# What if immunity is temporary?

- According to the WHO, there's no hard evidence of permanent immunity from infection with SARS-CoV-2.
- People do not acquire permanent immunity after exposure to other corona viruses (Shamanand and Galanti (2020)).
- With probability $\pi_s$, a recovered agent becomes susceptible again.
- Wu et al. (2007) report that SARS antibodies last on average for two years. So, we choose $\pi_s = 1/104$.

# Figure 10: Model with Re-infections, Testing and Containment



# Conclusion

- Testing allows the government to identify infected people and quarantine them.
- Non-test-based policies like lockdowns and other restrictions to economic activity improve upon the competitive equilibrium.
- Test-based quarantines ameliorate the sharp tradeoff between declines in economic activity and health outcomes that are associated with broad-based containment policies.
- This amelioration is particularly dramatic when people who recover from an infection acquire only temporary immunity to the virus.