What Does it Mean to Say That "The Path of the Economy Will Depend Significantly on the Course of the Virus"?

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• “The path of the economy will depend significantly on the course of the virus. The ongoing public health crisis will continue to weigh on economic activity, employment, and inflation in the near term, and poses considerable risks to the economic outlook over the medium term.”

• FOMC Statement September 2020

• What is the relationship between COVID and the economy?
Naive notions of a tradeoff between COVID deaths and the economy

Fernandez-Villaverde and Jones 2020

GDP LOSS (PERCENT)

- Shut down economy
- Keep economy open

COVID DEATHS PER MILLION PEOPLE
Naive notions of a tradeoff between COVID deaths and the economy

Fernandez-Villaverde and Jones 2020

GDP LOSS (PERCENT)

Bad policy or bad luck

Good policy or good luck

COVID DEATHS PER MILLION PEOPLE
How should we interpret this picture?

**Figure 1: Summary of the Trade-off Evidence**

- **GDP Loss**
  - **California** [lucky? too tight?]
  - Germany, Norway, Japan, S. Korea, China, Taiwan, Kentucky, Montana [lucky? good policy?]
  - New York City Lombardy United Kingdom Madrid [unlucky? bad policy?]
  - Sweden [unlucky? too loose?]

Fernandez-Villaverde and Jones 2020
No clear patterns in cumulative deaths and cumulative lost activity: Countries

International Covid Deaths and Lost GDP, 2020

Fernandez-Villaverde and Jones 2020
No clear patterns in cumulative deaths and cumulative lost activity: US States

U.S. States: Covid Deaths and Cumulative Excess Unemployment

Fernandez-Villaverde and Jones 2020
Plan for talk

- Assessing the tradeoff in a structural (SIR) model
- Prominent early assessments of impact of NPI’s
- Data on patterns in COVID transmission worldwide
- Economists’ assessments of the impact of NPI’s vs. Private Responses
- Adding endogenous behavior to the model
- “Luck” vs. “Policy” in a behavioral SIR model
- How will the pandemic weigh on economic activity going forward?
SIRD Model with transmission a function of time

\[
1 = S(t) + I(t) + R(t) + D(t)
\]

\[
\frac{dS(t)}{dt} = -\mathcal{R}(t)\gamma I(t)
\]

\[
\frac{dI(t)}{dt} = (\mathcal{R}(t) - 1)\gamma I(t)
\]

\[
\frac{dR(t)}{dt} = (1 - \nu)\gamma I(t)
\]

\[
\frac{dD(t)}{dt} = \nu\gamma I(t)
\]

\[
\mathcal{R}(t) \equiv \frac{\beta(t)}{\gamma} S(t)
\]

\[
\mathcal{R}(0) = \frac{\beta(0)}{\gamma}
\]

Effective Reproduction Number $\mathcal{R}(t)$

Recovery Rate $\gamma$

Infection Fatality Rate $\nu$

Transmission Rate $\beta(t)$

Normalized Transmission Rate $\frac{\beta(t)}{\gamma}$

Basic Reproduction Number $\mathcal{R}(0) = \frac{\beta(0)}{\gamma}$
Prominent Early Assessments of NPI’s

• Dehning et. al. Science 2020

• Flaxman et. al. Nature 2020

• Hsiang et. al. Nature 2020

• White and Hebert-Dufresne PLOS One 2020

• Estimate large impact of government mandated NPI’s on COVID transmission

• Transmission rate $\beta(t)$ assumed constant except for government mandated NPI’s

• Estimate large impact of government mandated NPI’s on activity and transmission
The Response of Activity
Policy or Private Behavior?

Worldwide seismic data from
Lecocq et. al. Science 2020

“Global quieting of high-frequency seismic noise due to covid-19 pandemic lockdown measures.”
COVID transmission around the World

Atkeson, Kopecky, and Zha 2020 updated to 9/9. 51 countries and 31 US States

1) Initial growth rates of daily deaths high and highly dispersed across locations

2) Growth rates of daily deaths falls towards zero rapidly. 20-30 days after 25 deaths

3) Cross-region dispersion in growth rates of daily deaths remains low

Is this all policy? Or is there some omitted variable(s)?
The Response of Activity
Big Drop and Slow Recovery

Figure 8a. Trend in mobility as measured through smartphone app use compared to January 2020 baseline.
In the United States, as of September 26, 2020, total spending by all consumers decreased by 4.7% compared to January 2020.
Worldwide Economic Impact
Big Drop and Slow Recovery

OECD Economic Outlook September 2020
World GDP, index 2019-Q4=100

Compare with June forecasts:

How do economists separate policy from behavior?
Goolsbee and Syverson 2020

Compare activity in nearby locations across state and county borders

Shutdown-Policy Differences and Consumer Activity: Iowa vs. Illinois

Map intended for illustrative purposes only
Source: Researchers’ calculations using data from SafeGraph
Behavior Equation applied to US counties

\[ Y_i(t) = \exp \left( -\sigma_i(t) \left( \frac{dC_i(t)}{dt} \right)^\rho + u_i(t) \right) \]

Estimate semi-elasticity function of observable county characteristics \( \sigma_i(t) \)

Daily confirmed cases \( \frac{dC_i(t)}{dt} \)

Estimate change in \( u_i(t) \) with timing of implementation of policies
Figure 5. Event study estimates: contact rate

Small estimated response of policies on activity

Arnon et. al. 2020
Decomposing the response of activity

As the number of COVID-19 cases surged in the second half of March and the geographic concentration of cases became apparent, the behavioral response shifted from nationwide fears to localized concerns reflecting the severity of local outbreaks. When the contact rate reached its lowest point in mid-April—a fall of almost 85% from the beginning of March—about 73% of the cumulative decline was attributable to precautionary behavior and 20% to local infection risk. The final component, state and local NPIs, explains only 7% of the change in the contact rate through mid-April.

Figure 8. Decomposition of the response to COVID-19
Contribution to log difference from March 1st, 7-day average

The decline in employment initially followed a pattern similar to the contact rate, lagging a few days behind. Precautionary behavior explains about 80% of the 11% fall in employment between March 8th and March 22nd. The two outcomes diverge beginning in late March due to the effects of NPIs—in particular, the employment impact of mandated business closures. By mid-April, employment was 20% below its level in early March. The response to local infection risk explains one fifth of this decline, the same as its contribution to the fall in the contact rate. State and local NPIs explains nearly 15%, more than double their contribution to the fall in the contact rate.

Mostly private responses

Source: Authors' calculations.
Adding Behavior to the SIR model
Interaction of Economics and Epidemics

**SIR Model**

\[
\text{Disease State} \quad S, I, R \quad + \quad \text{Transmission Rate} \quad \rightarrow \quad \text{Updated Disease State}
\]

**Transmission Rate Model**

\[
\text{Natural Forces, Human Activity, Prophylactic Use} \quad \rightarrow \quad \text{Transmission Rate}
\]

**Economic Model**

\[
\text{Information and Personal Risk/Reward, Policies} \quad \rightarrow \quad \text{Human Activity, Prophylactic Use}
\]
A Simple Behavioral SIR model

Transmission Equation

$$\beta_i(t) = \bar{\beta}_i Y_i(t)^\alpha \exp(v_i(t))$$

Region $i$
Activity $Y_i(t)$
$Y_i(0) = 1$

“Luck”
Basic Reproduction Number
$$R_i(0) = \frac{\bar{\beta}_i}{\gamma}$$

Elasticity of transmission wrt activity $\alpha > 0$
$$\alpha = 2?$$

Impact of prophylactics, Social distancing, ventilation etc
on transmission $v_i(t)$
$$v_i(0) = 0$$
A Simple Behavioral SIR model

Behavior Equation

\[ Y_i(t) = \exp \left( -\sigma_i \frac{dD_i(t)}{dt} + u_i(t) \right) \]

\[ \frac{dD_i(t)}{dt} \]

Region \( i \)

Daily Deaths

Policies like lockdown \( u_i(t) \)

\( u_i(0) = 0 \)

``policy''

Semi-elasticity of activity

wrt daily deaths

\( \sigma_i \geq 0 \)
What is the relationship between cumulative deaths and cumulative lost activity?

- “Luck” vs. “policy”
- Experiment 1: $\bar{\beta}_i$ differs across regions
- Experiment 2: $\sigma_i$ varies across regions
- All other parameters held constant across regions and experiments
- Simulate model for 180 days
- Cross section relationship between cumulative deaths and cumulative lost activity
Experiment 1: “Luck” Transmission

The effective reproduction number

$R_t$
Experiment 1: “Luck” Daily Deaths

![Graph of daily deaths over time]

- The graph shows the trend of daily deaths over 180 days.
- The x-axis represents the number of days, ranging from 0 to 180.
- The y-axis represents the number of daily deaths, ranging from 0 to 4.
- Three lines are plotted, each representing a different scenario or condition.
- The blue line starts with a sharp increase, reaching a peak around the 50th day.
- The red line has a similar trend but peaks later, around the 70th day.
- The yellow line increases more gradually, reaching its peak around the 100th day.
- After reaching their peaks, all lines show a decline, indicating a decreasing trend in daily deaths.

This experiment aims to analyze the impact of various factors on daily deaths, using a model that simulates real-world scenarios.
Experiment 1: “Luck” Activity
Experiment 1: “Luck” The Tradeoff
Naive notions of a tradeoff between COVID deaths and the economy

Fernandez-Villaverde and Jones 2020
Experiment 2: “Policy” Transmission

The effective reproduction number

Days

Rt

Days
Experiment 2: “Policy” Daily Deaths

The graph shows the daily deaths over time for different policies. The y-axis represents daily deaths, ranging from 0 to 10, and the x-axis represents days, ranging from 0 to 180. The blue line indicates a peak in daily deaths around day 50, followed by a decline. The orange line shows a lower and more gradual increase in daily deaths, peaking around day 100. The green line represents a steady, low increase in daily deaths throughout the observed period. The graph illustrates the impact of policies on daily deaths, with different strategies affecting the magnitude and timeline of these deaths.
Experiment 2: “Policy” Activity
Experiment 2: “Policy” The Tradeoff

Cumulative Deaths vs Log Cumulative Activity Loss
Naive notions of a tradeoff between COVID deaths and the economy

Fernandez-Villaverde and Jones 2020

GDP LOSS (PERCENT)

Shut down economy

Keep economy open

COVID DEATHS PER MILLION PEOPLE
“Luck” and “Policy” The Tradeoff

Cumulative Deaths vs Log Cumulative Activity Loss

Cumulative deaths per million at T

Log cumulative activity loss at T

Graph showing the relationship between cumulative deaths per million at T and log cumulative activity loss.
How should we interpret this picture?

Figure 1: Summary of the Trade-off Evidence

Fernandez-Villaverde and Jones 2020
How to think about economic recovery going forward
Forecasts for US Q3 GDP

Real Gross Domestic Product: Percent of Previous Peak

- Recession
- Real Gross Domestic Product (2012 Dollars)

Percent of Previous Peak:
- 100%
- 98%
- 96%
- 94%
- 92%
- 90%
- 88%

Years:
- 1959 to 2022

35% Annualized in Q3. Still down 3.3% from Q4
Worldwide Economic Impact
Big Drop and Slow Recovery

OECD Economic Outlook September 2020

World GDP, index 2019-Q4=100

Compare with June forecasts:

Longer Term Implications

Behavioral SIR Model

- Equilibrium effective reproduction number stays close to one
- Implies almost linear growth of cumulative deaths
- Slow recovery of activity raises transmission rate
- Balanced by slow depletion of susceptibles
- Economic recovery can take a long time!
Two year transition with differences in luck and policy
The pool of susceptibles

Log activity vs. daily deaths
Slow recovery of activity
Key questions for fostering recovery going forward

- Transmission equation
  - Can we slow transmission given the level of activity?
    - Masks, Testing contact tracing and isolation, etc.
- Behavior equation
  - Will pandemic fatigue raise the level of activity given deaths?
    - More deaths, less lost economic activity
- Vaccines
  - Can we deplete the pool of susceptibles faster?
Extra Slides
New deaths attributed to Covid-19 in European Union, United States, Brazil, United Kingdom, Spain and Italy

Seven-day rolling average of new deaths (per million), by number of days since 0.1 average daily deaths (per million) first recorded