Dynamics of the COVID Pandemic: A Nonequilibrium Approach

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April 26, 2021

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New Economic Thinking
AT THE OXFORD MARTIN SCHOOL

A model tailored to analyze COVID-19 pandemic

Key features of the economics of the pandemic

- **Supply shocks**: firms cannot operate/workers cannot work
- **Demand shocks**: lower aggregate demand and changes in preferences
- **Out-of-equilibrium dynamics**: sticky prices/excess demand or supply
- **Supply chain** coordination issues: substitutions, inventory dynamics
- Trade-off with **epidemic spreading**

We introduce dynamic IO model with inventories, out-of-equilibrium behaviour, a new production function, sectoral (and later regional) fidelity

Several related but distinct projects

Predicting shocks from first principles:

- del Rio-Chanona et al. [2020] (April), "Supply and demand shocks in the COVID-19 pandemic: An industry and occupation perspective." *Oxford Rev. of Econ. Policy*

Applying shocks in a dynamic IO model:

- Pichler et al. [2020] (May), "Production networks and epidemic spreading: How to restart the UK economy?"
- Pichler and Farmer [2021] (January) "Modeling simultaneous supply and demand shocks in input-output networks"
- Pichler et al. [2021] (February), "In and out of lockdown: Propagation of supply and demand shocks in a dynamic input-output model"

Work-in-progress:

- Pangallo et al., Working with epidemiologists on an epi-macro model calibrated on synthetic population data from the US.

Pandemic affects supply and demand

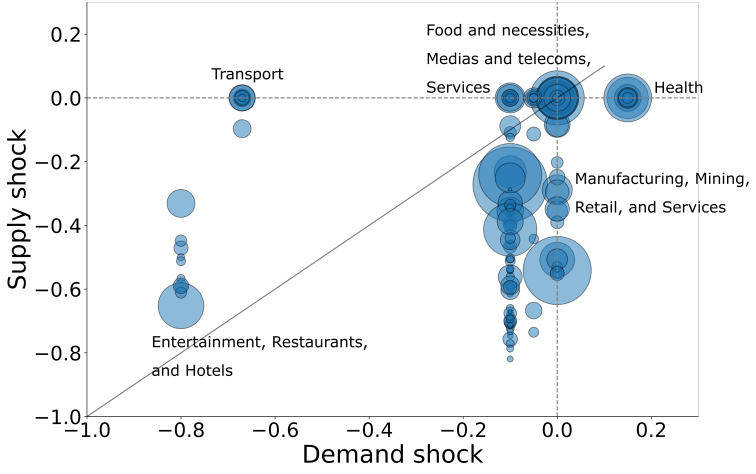
Supply shocks:

- **Remote-Labor-Index (RLI):** Coded *work activities* if can be done remotely and then mapped into occupations and industries.
- **Essentialness:** Some industries would still be allowed to operate (e.g. Electricity), and other would be mandated to close (e.g. Nightclubs).
- Workers that cannot work from home AND do not work in essential industries, will not be able to work.

Demand shocks: Adapted from Congressional Budget Office [2006].

- Transport: Essential, so open for business, but nobody wants to travel
- Manufacturing: Demand is still high but workers can't go to work
- Restaurants: Workers cannot go to work, but customers do not want to go anyway.

First-order shocks



First-order shocks in a full-fledged model

First-order shocks can (and do) have second-order effects.

- **Supply chains disruptions (upstream)** e.g. agriculture is essential, but many farmers have suffered reduced demand due to restaurant closures.
- **Supply chains disruptions (downstream)** e.g. workers in mining cannot work, so manufacturing workers face input restrictions.
- **Keynesian mechanisms** e.g. workers lose their job/income and reduce their demand
- Inventory holdings and input *criticality* will play a role

Supply and demand modules

Demand:

- Consumer demand depends on preferences, income and expectations
- Industries hold *input inventories* and place orders to maintain them. Calibrated to ONS inventory data

For similar inventory dynamics see Battiston et al. [2007]; Henriet et al. [2012]; Inoue and Todo [2019].

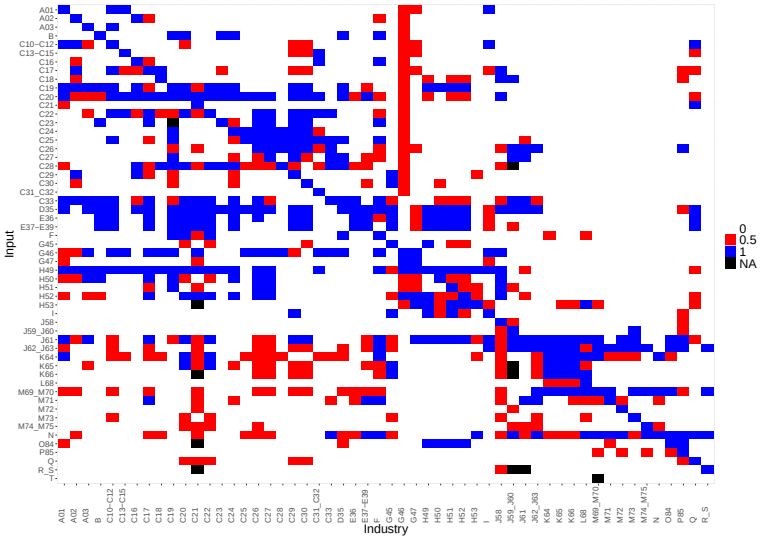
Supply:

- *Productive capacity:* Proportional to labor input
- *Input bottlenecks:* Leontief production only for *critical* inputs
- *Unsatisfied demand:* Firms ration proportionally

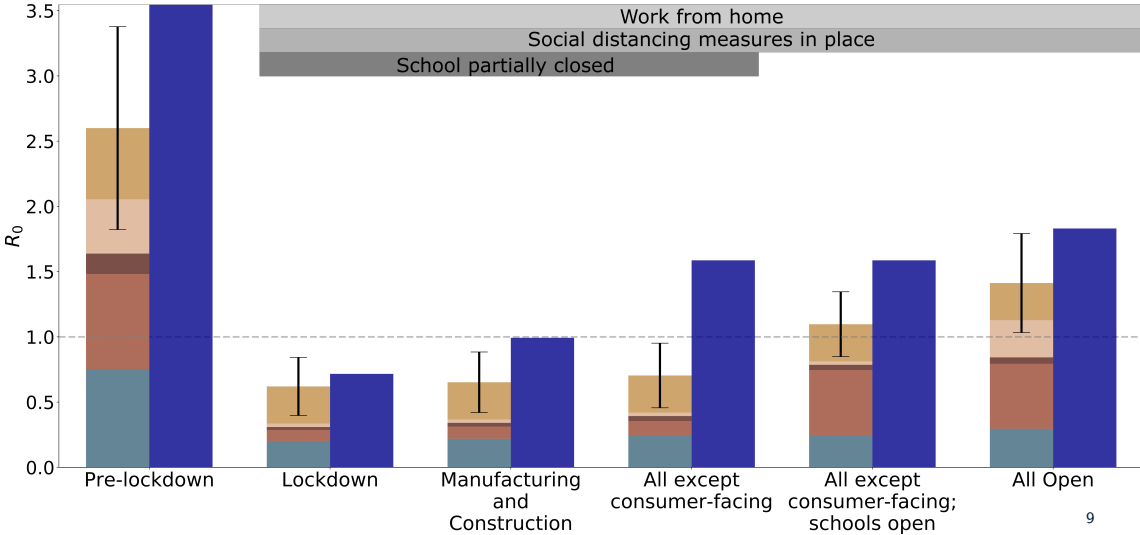
Rationing dynamics play key role in impact assessment [Pichler and Farmer, 2021].

What are critical inputs in economic production?

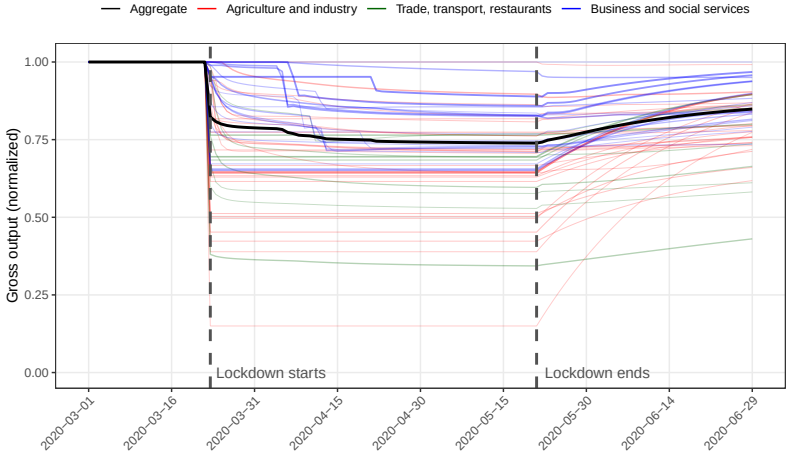
- IHS Markit industry analysts: "Can production continue in industry X if input Y is not available for two months?"
- Blue: critical, red: important, white: non-critical



Policy recommendation



Gross output of the UK economy



Q1/2020	GDP	Consumption
Data	-2%	-1.7%
Model	-1.7%	-1.3%

Post-mortem: Pichler et al. [2021]

In May, we published this prediction for the UK economy:

> *For 2020Q2, we forecast that GDP would be* **21.5%** *lower than in 2019Q4,*

At the time, the median forecast by several institutions and financial firms was 16.6% and the forecast by the Bank of England was 30%

Realized, based on ONS data: **-22.1%** (data revisions are about $\sim$ 1-2pp)

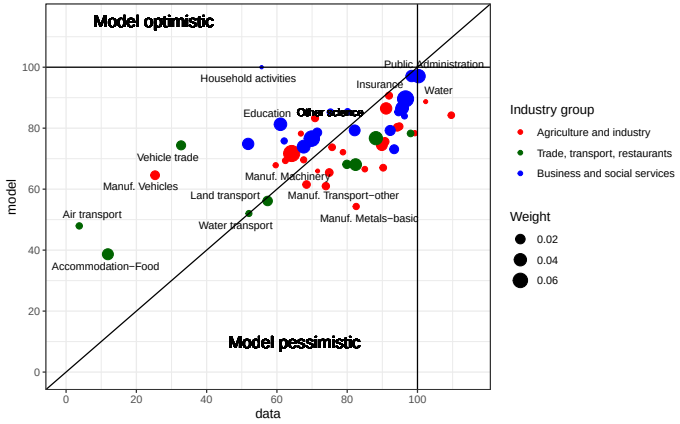
Variable (wrt. Q4-2019)	Data	Model
Gross output April	-27.4%	-25.3%
Gross output May	-25.2%	-26.9%
Gross output June	-17.8%	-16.8%
Value added Q2	-21.5%	-22.1%
Private cons. Q2	-25.3%	-21.3%
Investment Q2	-26.3%	-29.7%
Gov. consumption Q2	-17.5%	-14.2%
Inventories Q2	-2.2%	-0.5%
Exports Q2	-23.3%	-27.8%
Imports Q2	-30.6%	-23.9%
Wages & Salaries Q2	-1.1%	-4.3%
Profits Q2	-26.7%	-22.3%

Why did we do so well?

- **Aggregation.** Sectoral errors are larger ($\approx 12pp$), but they average out.
- **Sweet spot between shock severity and production function rigidity.** In the new version, we look at:
  - More supply shocks (less or more severe)
  - More versions of the production function (from Leontief to Linear, with our IHS "only-some-inputs-are-critical" in-between.
  - Other values for several other parameters.
  - Better data for inventories.

We conclude that we did well because we struck the right balance between shock severity and production function rigidity. The Leontief production function is much too rigid, linear not enogh

What are good sectoral predictions? Few papers compare their predictions to *sectoral* and *time series* data.



For a recent exception see Reissl et al. [2021]

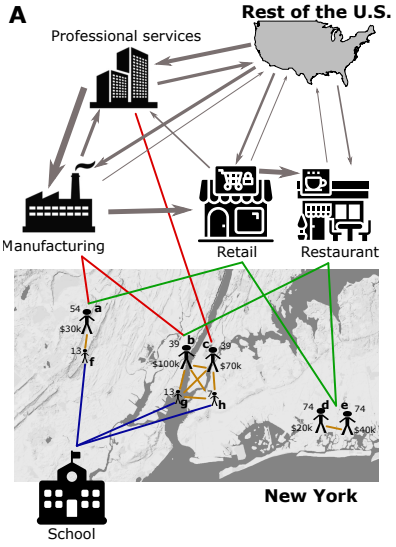
Work-in-progress: Coupling the economics with epidemiology

Working with epidemiologists on an epi-macro model calibrated on synthetic population data from the US. over

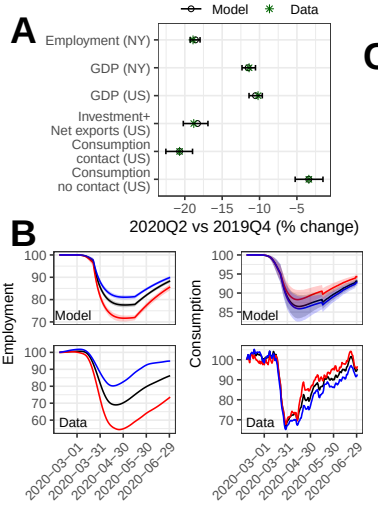
- 600k individuals, 300k households in New York Metro Area
- Individuals characterized by age, income, occupation, industry, remote working ability
- Data: Census ACS, BLS, BEA IO data, Cuebiq (contact matrices)
- People are quarantined if anyone in their household is positive. They cannot work.
- People's consumption depends (negatively) on the death rate.

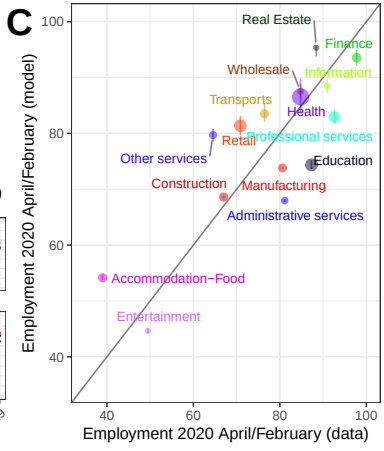
See epidemiological model in Aleta et al. [2020a,b]

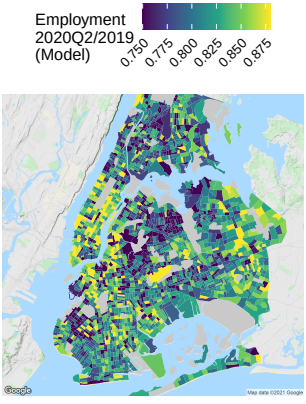
Model outline



Results


A
Model
Data
Employment (NY)
GDP (NY)
GDP (US)
Investment+
Net exports (US)
Consumption
contact (US)
Consumption
no contact (US)
−20
−15
−10
−5
2020Q2 vs 2019Q4 (% change)
B
Employment
Consumption
Model
Data
100
90
80
70
60
95
85
2020−03−01
2020−03−31
2020−04−30
2020−05−30
2020−06−29
All
Low income: < 27k$
High income: > 60k$


C
Employment 2020 April/February (model)
Employment 2020 April/February (data)
100
80
60
40
Real Estate
Finance
Wholesale
Information
Transports
Health
Retail
Professional services
Other services
Education
Construction
Manufacturing
Administrative services
Accommodation−Food
Entertainment


D
Employment
2020Q2/2019
(Model)
0.750
0.775
0.800
0.825
0.850
0.875
Google
Map data ©2021 Google

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Thank you!

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