Supply and Demand in Disaggregated Keynesian Economies with an Application to the Covid-19 Crisis

David Baqaee    Emmanuel Farhi

UCLA    Harvard

May 15, 2020
Question

- Covid-19 unusual aggregate shock.

- Mix of heterogeneous supply and demand shocks.

- Coexistence of tight and slack markets.

- Output, unemployment, inflation? Policy?
Use general disaggregated model and aggregate up.

Multiple sectors and factors, input-output linkages, elasticities.

Nominal rigidities, ZLB, credit constraints, firm failures...

Theoretical and quantitative results.
Agenda

Some Data Facts

Model Setup

Local Comparative Statics

Global Comparative Statics

Quantitative Illustration

Additional Results

Conclusion
Hours worked by sector
Nominal Spending

Aggregate and sectoral nominal spending
Inflation

(a) CPI inflation

(b) Prices by sector
Agenda

Some Data Facts

Model Setup

Local Comparative Statics

Global Comparative Statics

Quantitative Illustration

Additional Results

Conclusion
Proceed in Two Steps

- Start with neoclassical model.

- Then introduce Keynesian features: nominal rigidities and ZLB.
Neoclassical Model Structure

- $N$ produced goods.
- $G$ factors in inelastic supply.
- Homothetic final demand.
- Goods produced using other goods and factors.
Final Demand

- Final demand maximizes homothetic aggregator:
  
  \[ \mathcal{D}(c_1, \ldots, c_N; \omega_D) \]

- Budget constraint:
  
  \[ \sum_{i \in \mathcal{N}} p_i c_i = \sum_{f \in \mathcal{F}} w_f \bar{L}_f + \sum_{i \in \mathcal{N}} \pi_i. \]

- Inelastic factor supplies \( \bar{L}_f \).
Good $i$ produced under constant returns:

$$y_i = A_i F_i (x_{i1}, \ldots, x_{iN}, L_{i1}, \ldots, L_{iG}).$$

Producer $i$ maximizes profits:

$$\pi_i = \max_{\{y_i\}, \{x_{ij}\}, \{L_{if}\}} p_i y_i - \sum_{j \in \mathcal{N}} p_j x_{ij} - \sum_{f \in \mathcal{G}} w_f L_{if}.$$
Neoclassical Equilibrium

- Agents optimize.

- Markets clear.
Keynesian Model

- Two periods: present and future.

- Utility maximization s.t. intertemporal budget constraint.

- Present: same as before + downward nominal wage rigidity.

- Future: full employment + fixed nominal expenditure.

- Monetary policy: full employment s.t. ZLB.
Equilibrium in Factor Markets

(a) Factors in $\mathcal{H}$

(b) Factors in $\mathcal{L}$

- “Capitals” $f \in \mathcal{H}$: always flexible.
- “Labors” $f \in \mathcal{L}$: flexible ($f \in \mathcal{F}$) or rigid ($f \in \mathcal{R}$) in equilibrium.
Comparative Statics

- Perturb initial equilibrium with shocks:
  - supply shocks $A_i$ and $\bar{L}_f$;
  - demand shocks $\omega_D$ and $\zeta$.

- Local and global comparative statics.
Agenda

Some Data Facts

Model Setup

Local Comparative Statics

Global Comparative Statics

Quantitative Illustration

Additional Results

Conclusion
Intertemporal Euler Equations

- Log-linearized Euler equation:
  \[ d \log Y = -\rho d \log p^Y + d \log \zeta. \]

- Aggregate demand (AD) shock:
  \[ d \log \zeta = -\rho \left( d \log (1 + i) + d \log \beta - d \log \bar{p}_*^Y \right) + d \log \bar{Y}_*. \]

- Negative shocks to labor supplies and shocks to composition of demand reduce output and increase prices (stagflationary).

- Negative AD shock reduce output and prices (deflationary).
Intertemporal Euler Equations

- Euler equation for aggregate nominal expenditure $E = p^Y Y$:
  \[d \log E = (1 - \rho)d \log p^Y + d \log \zeta.\]

- Focus on $\rho = 1$ nominal expenditure exogenous:
  \[d \log E = d \log \zeta.\]
Intratemporal Aggregation Equation

- Changes in output are given by

\[
d \log Y = \sum_{i \in \mathcal{N}} \lambda_i d \log A_i + \sum_{f \in \mathcal{G}} \lambda_f d \log \bar{L}_f
\]

\[
+ \sum_{f \in \mathcal{L}} \lambda_f \min \left\{ d \log \lambda_f + d \log E - d \log \bar{L}_f, 0 \right\}.
\]

- Changes in factor supplied are given by

\[
d \log L_f = \begin{cases} 
  d \log \bar{L}_f, & \text{for } f \in \mathcal{K}, \\
  \min \left\{ d \log \lambda_f + d \log E, d \log \bar{L}_f \right\}, & \text{for } f \in \mathcal{L}.
\end{cases}
\]
Intratemporal Propagation Equations

- Changes in sales and factor shares are given by

\[
d \log \lambda_k = \theta_0 \text{Cov}_{\Omega(0)} \left( d \log \omega_0, \frac{\Psi^{(k)}}{\lambda_k} \right) \\
+ \sum_{j \in 1+N} \lambda_j \left( \theta_j - 1 \right) \text{Cov}_{\Omega(j)} \left( \sum_{i \in N} \Psi^{(i)} d \log A_i - \\
\sum_{f \in \mathcal{G}} \Psi^{(f)} \left( d \log \lambda_f - d \log L_f \right) + \frac{\Psi^{(k)}}{\lambda_k} \right).
\]

- Role of network \((\Omega, \Psi')\) and elasticities \((\theta_j)\).
Agenda

Some Data Facts

Model Setup

Local Comparative Statics

Global Comparative Statics

Quantitative Illustration

Additional Results

Conclusion
Benchmark with Simple Network Sufficient Statistics

- Assume uniform elasticities ($\theta_j = \theta$), unitary IES ($\rho = 1$).

- Assume only factor-supply shocks and AD shocks.

- Initial factor shares global sufficient statistics for network!

- Break (see paper): non-uniform elasticities or other shocks.
Complements vs. Substitutes

- Assume only factor-supply shocks (generalizes to AD shocks).

- With substitutes ($\theta > 1$):
  - reduction in labor supplied *increases* demand for other labors;
  - no Keynesian unemployment.

- With complements ($\theta < 1$):
  - reduction in labor supplied *reduces* demand for other labors;
  - Keynesian unemployment (factors with smallest supply shocks).
Global Comparative Statics with Complements ($\theta < 1$)

- Set of equilibrium vectors $\Delta \log L$ is lattice (with $\leq$).

- Unique best and worst equilibrium.

- $\Delta \log Y$ and $\Delta \log L$ increasing in $\Delta \log \bar{L}$ and $\Delta \log \zeta$.

- $\Delta \log p^Y$ decreasing in $\Delta \log \bar{L}$ and increasing in $\Delta \log \zeta$. 
AS-AD Diagrams

- Two labor markets, supply reduction in one.
- AS shifts: recession and inflation (stagflation).
- AS changes shape: nonlinearities (amplification, interaction).
Two equal-sized labor markets, 20% supply reduction in one.

Unemployment increasing in complementarities.

Output gap hump-shaped in complementarities.
Two equal-sized labor markets, supply reduction in one vs. both.

Output gap increasing in supply shock heterogeneity.
Interaction of Supply and AD Shocks

- AD shock reduces output if large compared to supply shock.
- AD shock always reduces inflation (deflationary).
- Output gap from AD shock mitigated by complementarities.
Shocks to Composition of Final Demand

- See paper.

- Even with uniform elasticities, need new network sufficient statistics beyond initial factor income shares $\bar{\lambda}_f$:

$$\Delta \log \bar{\lambda}_f = \sum_{j \in \mathcal{N}} \bar{\Omega}_0 j \exp(\Delta \log \omega_0 j) \Psi_{jf}.$$ 

- Need network-adjusted factor intensities $\Psi_{jf}$.

- Shock to composition of final demand: stagflationary, resulting output gaps amplified by complementarities.
Agenda

Some Data Facts

Model Setup

Local Comparative Statics

Global Comparative Statics

Quantitative Illustration

Additional Results

Conclusion
Quantitative Illustration

- Stylized version of U.S. economy: 66 sectors, sectoral production using capital, labor, and intermediates.

- Factors cannot be reallocated across sectors (short run).

- Elasticities \((\sigma, \theta, \varepsilon, \eta) = (0.8, 0.1, 0.5, 1)\).

- Pick shocks to match data: reduction in aggregate nominal expenditure \((\sim -15\%)\), hours worked by sector \((\sim -15\%\) on average), and mild deflation \((-0.8\%)\).

- Two scenarios (identification problem):
  - negative AD shocks and negative labor-supply shocks;
  - negative AD shocks and composition-of-demand shocks.
Negative Labor-Supply and AD Shocks

- Fix negative AD shock and scale negative labor-supply shocks.
- Supply shocks only: some unemployment and inflation.
- Supply and AD shocks: high unemployment and deflation.
Role of Complementarities

- Compare to more or less complementarities.
- Complementarities mitigate negative AD shock.
- Complementarities amplify negative supply shocks.
## Composition-of-Demand and AD Shocks

<table>
<thead>
<tr>
<th></th>
<th>Real GDP</th>
<th>Inflation</th>
<th>Unemployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sticky Labor</td>
<td>-0.08</td>
<td>-0.04</td>
<td>0.15</td>
</tr>
<tr>
<td>Sticky Labor and Capital</td>
<td>-0.12</td>
<td>0.00</td>
<td>0.16</td>
</tr>
</tbody>
</table>

- Sticky labor: unemployment and deflation.
- Sticky labor and capital: more unemployment and less deflation.
- Sticky capital? Capital under-utilization and firm failures.
Agenda

Some Data Facts

Model Setup

Local Comparative Statics

Global Comparative Statics

Quantitative Illustration

Additional Results

Conclusion
More in Paper

- More examples of network effects with non-uniform elasticities.
- Endogenous demand shocks from credit constraints.
- Endogenous supply shocks from business failures.
- Policy: conventional and unconventional monetary policy, targeted fiscal stimulus, payroll tax cuts, transfers...
Agenda

Some Data Facts

Model Setup

Local Comparative Statics

Global Comparative Statics

Quantitative Illustration

Additional Results

Conclusion
Conclusion

- Covid-19 unusual aggregate shock: mix of heterogeneous supply and demand shocks; coexistence of tight and slack markets.

- Must use disaggregated model to understand macro implications!

- Must use as much disaggregated data as available.

- Not a “big mess”: clear theoretical and quantitative lessons.

- Next steps: revisit numbers as disaggregated data becomes available, make progress on identification problem.