Demand Composition and the Strength of Recoveries

Martin Beraja  Christian Wolf
MIT            Chicago

March 2021
Consumer theory: *pent-up demand* is stronger for *durables*.
Consumer theory: **pent-up demand** is stronger for **durables**.

Q: What does this imply for how spending composition affects recoveries?

variation across recessions: (i) long-run shares, (ii) sectoral shock incidence
Consumer theory: **pent-up demand** is stronger for **durables**.

Q: What does this imply for how spending composition affects recoveries?

variation across recessions: (i) long-run shares, (ii) sectoral shock incidence

1. **Theory**
   - Multi-sector model with demand-determined output + demand shocks
   - Derive *testable condition* for pent-up demand effects to be strong enough
Consumer theory: **pent-up demand** is stronger for **durables**.

Q: What does this imply for how spending composition affects recoveries?

variation across recessions: (i) long-run shares, (ii) sectoral shock incidence

1. **Theory**

   - Multi-sector model with demand-determined output + demand shocks
   - Derive *testable condition* for pent-up demand effects to be strong enough

     If condition holds, recoveries from recessions concentrated in **services** are weaker than recoveries from recessions biased towards **durables**
Consumer theory: **pent-up demand** is stronger for **durables**.

**Q**: What does this imply for how spending composition affects recoveries?

variation across recessions: (i) long-run shares, (ii) sectoral shock incidence

1. **Theory**

   - Multi-sector model with demand-determined output + demand shocks
   - Derive *testable condition* for pent-up demand effects to be strong enough
     
     If condition holds, recoveries from recessions concentrated in **services** are weaker than recoveries from recessions biased towards **durables**

2. **Measurement & quantification**

   - a) Test key condition using aggregate time series evidence
   - b) Quantify effect of composition on recovery strength
Consumer theory: pent-up demand is stronger for durables.

Q: What does this imply for how spending composition affects recoveries?

variation across recessions: (i) long-run shares, (ii) sectoral shock incidence

1. Theory

- Multi-sector model with demand-determined output + demand shocks
- Derive testable condition for pent-up demand effects to be strong enough

If condition holds, recoveries from recessions concentrated in services are weaker than recoveries from recessions biased towards durables

2. Measurement & quantification

a) Test key condition using aggregate time series evidence
b) Quantify effect of composition on recovery strength

3. Discuss implications for optimal monetary policy
Related Literature

1. Sectoral heterogeneity & business cycle dynamics
   ○ Heterogeneity on the supply-side
     - Networks: Carvalho & Grassi (2019), Bigio & La’O (2020)

2. Strength & shape of recoveries
   ○ Nature of shocks: Gali et al. (2012), Beraja et al. (2019)
   ○ Structural forces: Fukui et al. (2018), Fernald et al. (2017)
   ○ Others: Hall (2016), Coibion et al. (2013), Kozlowski et al. (2020)

3. COVID-19 recession
   ○ Sectoral incidence: Chetty et al. (2020), Cox et al. (2020), Guerrieri et al. (2020)
   ○ Recovery shapes: Reis (2020), Gregory & Menzio (2020)
Theory
Model Overview

• Environment: **textbook NK model + multiple sectors**

1. **Representative household:** consume **durables** and **services**

2. **Rest of the economy**
   a) Labor-only production of intermediates, fixed rel. price of durables & services
   b) Nominal rigidities in price- & wage-setting
   c) Nominal rate set by monetary authority
Model Overview

• Environment: **textbook NK model + multiple sectors**

  1. **Representative household**: consume **durables** and **services**

  2. **Rest of the economy**
     a) Labor-only production of intermediates, fixed rel. price of durables & services
     b) Nominal rigidities in price- & wage-setting
     c) Nominal rate set by monetary authority

• **Agg. risk**: shocks to agg. demand $b_c^t$ and sectoral demand $\{b_d^t, b_s^t\}$
Household

- **Preferences**

\[ E_0 \left[ \sum_{t=0}^{\infty} \beta^t \{ u(s_t, d_t; b_t) - v(\ell_t; b_t) \} \right] \]

where

\[ u(s, d; b) = \frac{e^{b^c + b^s \phi \zeta s^{1-\zeta}} + e^{\alpha(b^c + b^d)(1 - \tilde{\phi})\zeta d^{1-\zeta}}}{1 - \gamma} \]

\[ v(\ell; b) = e^{s^c b^c + s^s b^s + s^d b^d} \frac{\ell^{1+\frac{1}{\phi}}}{1 + \frac{1}{\phi}} \]

- \( b^c_t \): aggregate demand shifter (uncertainty, income risk, deleveraging, …)
  Note: \( b^c_t \) has no real effects in flex-price eq’m = multi-sector notion of “agg. demand”

- \( \{ b^s_t, b^d_t \} \): sectoral demand shifters (preference changes, disease risk, …)
  Note: \( b^s_t = b^d_t \) acts like the common agg. demand shock \( b^c_t \)
Household

• Preferences

\[ \mathbb{E}_0 \left[ \sum_{t=0}^{\infty} \beta^t \{ u(s_t, d_t; b_t) - v(l_t; b_t) \} \right] \]

where

\[ u(s, d; b) = \frac{e^{b^c + b^s \phi} s^{1-\zeta} + e^{\alpha(b^c + b^d)} (1 - \phi) \zeta d^{1-\zeta}}{1 - \gamma} \]

\[ v(l; b) = e^{\zeta c b^c + s_3 b^s + s_d b^d} \frac{l^{1+1/\phi}}{1 + 1/\phi} \]

○ \( b^c_t \): aggregate demand shifter (uncertainty, income risk, deleveraging, ...)
  Note: \( b^c_t \) has no real effects in flex-price eq’m = multi-sector notion of “agg. demand”

○ \( \{ b^s_t, b^d_t \} \): sectoral demand shifters (preference changes, disease risk, ...)
  Note: \( b^s_t = b^d_t \) acts like the common agg. demand shock \( b^c_t \)

• Budget constraint

\[ s_t + \underbrace{[d_t - (1 - \delta)d_{t-1}]}_{e_t} + \frac{\kappa}{2} \left( \frac{d_t}{d_{t-1}} - 1 \right)^2 d_t + a_t = w_t l_t + \frac{1 + r_{t}^{n}}{1 + \pi_t} a_{t-1} + q_t \]
Theory

Intuition in a Special Case
• **Special case**: $\zeta = \gamma$, no adj. costs, iid shocks, fixed prices
  → implies: fully demand-determined output $\hat{y}_t = \phi \hat{s}_t + (1 - \phi) \hat{e}_t$

  ○ Look at impulse responses to shocks \( \{ b_0^c, b_0^s, b_0^d \} \)

  ○ Focus on recovery dynamics (shape), fixing severity of recession (scale)
The Pent-Up Demand Mechanism

- **Special case:** $\zeta = \gamma$, no adj. costs, iid shocks, fixed prices

1. Services demand shock $b_t^S$: no pent-up demand, lost output is foregone
The Pent-Up Demand Mechanism

- **Special case**: $\zeta = \gamma$, no adj. costs, iid shocks, fixed prices

1. Services demand shock $b_t^s$: no pent-up demand, lost output is foregone

$$\hat{y}^s \equiv \sum_{t=0}^{\infty} \frac{\hat{y}_t^s}{\hat{y}_0^s}$$

Measures weakness of the reversal of output. Stronger recovery = smaller normalized CIR
The Pent-Up Demand Mechanism

- **Special case:** $\zeta = \gamma$, no adj. costs, iid shocks, fixed prices

1. Services demand shock $b_t^s$: no pent-up demand, lost output is foregone

$$\hat{y}^s = \frac{-1 + 0}{-1} = 1$$
The Pent-Up Demand Mechanism

- **Special case**: $\zeta = \gamma$, no adj. costs, iid shocks, fixed prices

2. Durables demand shock $b^d_t$: recovery boosted by pent-up demand
The Pent-Up Demand Mechanism

- **Special case**: $\zeta = \gamma$, no adj. costs, iid shocks, fixed prices

2. Durables demand shock $b_t^d$: recovery boosted by pent-up demand

$$\hat{y}^d = \frac{-1 + (1 - \delta)}{-1} = \delta$$
• **Special case:** $\zeta = \gamma$, no adj. costs, iid shocks, fixed prices

3. Aggregate demand shock $b_t^c$: hybrid case

$$\hat{y}^c = 1 - \frac{1 - \phi}{\phi(1 - \beta(1 - \delta))\delta + 1 - \phi} (1 - \delta)$$
The Pent-Up Demand Mechanism

- **Special case**: $\zeta = \gamma$, no adj. costs, iid shocks, fixed prices

4. For any $\{b^c_t, b^s_t, b^d_t\}$, let impact services share be $\omega = \frac{\phi \hat{s}_0}{\phi \hat{s}_0 + (1-\phi) \hat{e}_0}$. Then:

$$\hat{y} = 1 - (1 - \omega)(1 - \delta)$$

$\implies$ the larger the services share $\omega$, the weaker the recovery
Theory

Back to the Full Model
Does this result survive in the full model?

- Setting: full model + two simplifications
  
  (i) Separable preferences over durables & services ($\gamma = \zeta$)
  
  (ii) Passive monetary policy, fixes (expected) real rate
    
    Equivalent to fixed prices + fixed nominal rate
Does this result survive in the **full model**?

- Setting: full model + two simplifications
  
  (i) Separable preferences over durables & services ($\gamma = \zeta$)
  
  (ii) Passive monetary policy, fixes (expected) real rate
  
  Equivalent to fixed prices + fixed nominal rate

- Find: not necessarily, since pent-up demand can be offset by adj. costs

**Proposition**

For any vector of time-0 shocks $\{b_{0}^{c}, b_{0}^{d}, b_{0}^{d}\}$,

$$\hat{y} = \frac{1}{1 - \rho_b} \left[ 1 - (1 - \omega)(1 - \frac{\delta}{1 - \theta_d}) \right]$$
Does this result survive in the full model?

- Setting: full model + two simplifications
  1. Separable preferences over durables & services ($\gamma = \zeta$)
  2. Passive monetary policy, fixes (expected) real rate
     Equivalent to fixed prices + fixed nominal rate

- Necessary and sufficient condition in terms of measurable objects $s^c$ & $e^c$

**Proposition**

Let $s^c$ and $e^c$ denote the services and durables nCIRs to the aggregate demand shock $b_0^c$. Then, given $\{b_0^c, b_0^s, b_0^d\}$, $\hat{y}$ is increasing in $\omega$ if and only if

$$s^c > e^c$$
The Full Model (II)

Results extend to:

1. **Incomplete markets**: fraction $\mu$ of hand-to-mouth households
2. **Many sectors**: $N$ sectors heterogeneous in durability and adj. costs
3. **Supply shocks**: shocks to relative productivity of different sectors
4. **General adjustment shocks**: $\psi(\{d_{t-\ell}\}_{\ell=0}^{\infty})$
The Full Model (II)

Results extend to: 

1. **Incomplete markets**: fraction $\mu$ of hand-to-mouth households
2. **Many sectors**: $N$ sectors heterogeneous in durability and adj. costs
3. **Supply shocks**: shocks to relative productivity of different sectors
4. **General adjustment shocks**: $\psi(\{d_{t-\ell}\}_{\ell=0}^{\infty})$

What if $\zeta \neq \gamma$, partially sticky prices, and active monetary rule?

$$\hat{y} = \frac{1}{1 - \rho_b} \left[ 1 - (1 - \omega)(1 - \frac{\delta}{1 - \theta_d}(1 + \frac{\phi}{1 - \phi \theta_s})) \right]$$

- Additional persistence through effect of $\hat{d}_{t-1}$ on $\hat{s}_t$
The Full Model (II)

Results extend to:

1. **Incomplete markets**: fraction $\mu$ of hand-to-mouth households
2. **Many sectors**: $N$ sectors heterogeneous in durability and adj. costs
3. **Supply shocks**: shocks to relative productivity of different sectors
4. **General adjustment shocks**: $\psi(\{d_{t-\ell}\}_{\ell=0}^{\infty})$

What if $\zeta \neq \gamma$, partially sticky prices, and active monetary rule?

$$\hat{y} = \frac{1}{1 - \rho_b} \left[ 1 - (1 - \omega)(1 - \frac{\delta}{1 - \theta_d}(1 + \frac{\phi}{1 - \theta_s})) \right]$$

- Additional persistence through effect of $\hat{d}_{t-1}$ on $\hat{s}_t$
- Condition $\hat{s}^c > \hat{e}^c$ may be necessary, not sufficient
- Numerically: wide range of calibrations where $\hat{s}^c > \hat{e}^c$ also imply $\frac{\partial \hat{y}}{\partial \omega} > 0$
Measurement
Hypothesis: If spending cuts in a demand-driven recession are concentrated in services, then the recovery is hampered by weak pent-up demand.
Empirical Evidence

**Hypothesis**: If spending cuts in a demand-driven recession are concentrated in services, then the recovery is hampered by weak pent-up demand.

- **Test**: true if and only if sectoral nCIRs satisfy

\[ s^c > e^c \]
Hypothesis: If spending cuts in a demand-driven recession are concentrated in services, then the recovery is hampered by weak pent-up demand.

• **Test**: true if and only if sectoral nCIRs satisfy

\[ s^c > e^c \]

• **Ideal laboratory**: monetary policy shocks

1. Equivalent to aggregate demand shocks in our model

2. Relatively standard approach to time series identification is available


**Today**: simple recursive VAR
Hypothesis: If spending cuts in a demand-driven recession are concentrated in services, then the recovery is hampered by weak pent-up demand.

• **Test**: true if and only if sectoral nCIRs satisfy

\[ s^c > e^c \]

• **Ideal laboratory**: monetary policy shocks

1. Equivalent to aggregate demand shocks in our model

2. Relatively standard approach to time series identification is available


**Today**: simple recursive VAR

• **In paper**: other shocks (e.g., uncertainty)
⇒ services nCIR is **88%** larger than durables nCIR (**22%** for non-durables)

○ Note: consistent with previous work documenting overshoot in durables

*Erceg-Levin (2006), McKay-Wieland (2020)*
Finer responses: services pent-up demand?
Recovery strength across U.S. states

- Olney-Pacitti (2017)
  *Longer* employment recovery in states providing services than goods
- Redo exercise measuring objects consistent with the theory (nCIR, $\omega$)
Recovery strength across U.S. states

- **Olney-Pacitti (2017)**
  - *Longer* employment recovery in states providing services than goods
- Redo exercise measuring objects consistent with the theory (nCIR, $\omega$)

![Graph showing normalized CIR 12 months following state-specific trough in terms of employment.]

Normalized CIR is measured as the cumulated percent change in employment from peak divided by the percent change in employment from peak to trough. Observations where the normalized CIR was below 20 were dropped.
Quantification
Quantification

Two main reasons to expect variation in demand composition

1. Fixed agg. demand shock $b_t$, but changing long-run shares $\phi$
Quantification

Two main reasons to expect variation in demand composition

1. Fixed agg. demand shock $b_t$, but changing long-run shares $\phi$
Quantification

Two main reasons to expect variation in demand composition

2. Fixed shares $\phi$, but changing shock combinations $\{b_t^c, b_t^s, b_t^d\}$
Two main reasons to expect variation in demand composition

2. Fixed shares $\phi$, but changing shock combinations $\{b_t^c, b_t^s, b_t^d\}$
Approach 1: counterfactuals using semi-structural shift-share

• Idea: re-weight sectoral IRFs to monetary shock to match desired sectoral spending composition

• Recovers “true” output IRF in model with: $\zeta = \gamma$, passive MP, and demand shocks as persistent as MP shock.

• Works for either source of variation, i.e., counterfactual $\phi$ or $\{b^c_t, b^s_t, b^d_t\}$. 

Result
Semi-structural Shift-share

Output nCIR to agg. demand shock for varying expenditure shares

E.g., nCIR for **Canada shares** ≈ 15% smaller than **U.S. shares**
Semi-structural Shift-share

Output IRF to shock combinations reproducing recession composition

E.g., nCIR for **COVID-19 shares** ≈ 70% larger than w/ **avg. shares**
Approach 2: counterfactuals in range of fully parameterized structural models

- Setting: full model, explore nCIRs across parameter space

  1. Strength of **adjustment costs**
  2. Monetary **policy rule** & **price stickiness**
  3. **Persistence** of the demand shocks \( \{ b^C_t, b^S_t, b^d_t \} \)

\[ \Rightarrow \text{Robustly find the expected large nCIR differences} \]
Structural model

- **COVID-19 shares** vs. **avg. recession shares** nCIR ratio:

For preferred calibration, similar magnitude than following shift-share approach
Policy Implications
Policy Implications

Large effects of demand composition. Implications for optimal policy?
Policy Implications

Large effects of demand composition. Implications for **optimal policy**?

1. Aggregate demand shocks $b^c_t$ with changing long-run shares

E.g.: How should central banks behave in more services-intensive economies?

- Optimal monetary policy is **independent** of services share $\phi$  
- Intuition: transmission of both $b^c_t$ and interest rates $r^n_t$ are equally affected
- Knife-edge result. But illustrates more general principle...
Policy Implications

Large effects of demand composition. Implications for optimal policy?

1. Aggregate demand shocks $b^c_t$ with changing long-run shares
   E.g.: How should central banks behave in more services-intensive economies?
   - Optimal monetary policy is independent of services share $\phi$ ➤ Proposition
   - Intuition: transmission of both $b^c_t$ and interest rates $r^n_t$ are equally affected
   - Knife-edge result. But illustrates more general principle...

2. Fixed long-run shares with changing shock incidence $\{b^c_t, b^s_t, b^d_t\}$
   E.g.: How should central banks respond to services-led recessions?
   - Ease for longer if recession is biased towards services ➤ Proposition & illustration
Conclusions

Basic consumer theory + Demand-determined output

\[ \downarrow \]

Demand composition matters for strength of recoveries

1. Key **testable implication** receives strong support in U.S. time series

2. Demand composition effects can be **quantitatively meaningful**

3. Implications for optimal **stabilization policy**
   a) No obvious **intertemporal trade-off**: pent-up demand for shocks & policy
   b) Hike rates **too fast** if services recession is treated like an avg. recession
Thank you!
1. **Unions**

   - Standard wage-setting protocol gives

   \[
   \hat{\pi}_t^w = \frac{(1 - \beta \phi_w)(1 - \phi_w)}{\phi_w(\frac{\varepsilon_w}{\varphi} + 1)} \left[ \frac{1}{\varphi} \hat{l}_t - (\hat{w}_t + \hat{\lambda}_t - (s_c b^c_t + s_s b^s_t + s_d b^d_t)) \right] + \beta E_t [\hat{\pi}^w_{t+1}]
   \]

   where \(\lambda_t\) is the marginal utility of wealth

2. **Producers**

   - Labor-only production and nominal rigidities give price-NKPC:

   \[
   \hat{\pi}_t = \zeta_p \left( \hat{w}_t - \frac{y''(\ell)}{y'(\ell)} \hat{\ell}_t \right) + \beta E_t [\hat{\pi}_{t+1}]
   \]

3. **Policy**

   - Consider baseline rule

   \[
   \hat{r}_t^n = \phi_\pi \hat{\pi}_t
   \]

   - For analytical results, consider limit case \(\phi_\pi \to 1^+\)
Recession dynamics in the full model

- The sectoral spending impulse responses satisfy

\[ \hat{s}_t = \frac{1}{\gamma} (b_0^c + b_0^s) \rho_b^t, \quad \hat{e}_t = \frac{1}{\gamma} (b_0^c + b_0^d) \frac{\theta_b}{\theta} \left( \rho_b^t - (1 - \delta - \theta_d) \frac{\theta_d^t - \rho_b^t}{\theta_d - \rho_b} \right) \]

- For aggregate output we thus get

\[ \hat{y}_t = \phi \hat{s}_0 \rho_b^t + (1 - \phi) \hat{e}_0 \left( \rho_b^t - (1 - \delta - \theta_d) \frac{\theta_d^t - \rho_b^t}{\theta_d - \rho_b} \right) \]

- The CIR to a generic shock mix \( \{b_t^c, b_t^s, b_t^d\} \) thus satisfies

\[ \hat{y} = \frac{1}{1 - \rho_b} \left[ 1 - (1 - \omega)(1 - \frac{\delta}{1 - \theta_d}) \right] \]
• Incomplete markets
  
  ○ A fringe $\mu$ of households has the same preferences, but is hand-to-mouth
  ○ Assume their income follows
  
  $$\phi \hat{s}^H_t + (1 - \phi) \hat{e}^H_t = \eta \hat{y}_t$$

  $\Rightarrow$ Irrelevance result: HtMs scale IRFs up or down, but leave shapes unchanged

• Supply shocks
  
  ○ Intermediate good is turned into services at rate $z^s_t$ and durables at rate $z^d_t$
  ○ Then supply shocks show up in two places:

    1. Prices in the household budget constraint satisfy

       $$\hat{p}^s_t = -\hat{z}^s_t, \quad \hat{p}^d_t = -\hat{z}^d_t$$

    2. The output market-clearing condition becomes

       $$\hat{y}_t = \phi(-\hat{z}^s_t + \hat{s}_t) + (1 - \phi)(-\hat{z}^d_t + \hat{e}_t)$$
• N sectors
  ○ Household preferences over consumption bundles are now
    \[
    u(d; b) = \frac{\left(\sum_{i=1}^{N} e^{\alpha_i (b^c + b^i)} \phi_i d_{it}^{1-\zeta} \right)^{\frac{1-\gamma}{1-\zeta}} - 1}{1 - \gamma}
    \]
  ○ CIR satisfies
    \[
    \hat{y} = - \sum_{i=1}^{N} \omega_i \frac{\delta_i}{1 - \theta_d^i} = - \sum_{i=1}^{N} \omega_i e_i^c
    \]

• General adjustment costs
  ○ Consider a general specification:
    \[
    \psi(\{d_{t-\ell}\}_{\ell=0}^\infty)
    \]
  ○ Key insight: does not affect separability of the system
Monetary policy vs. demand shocks

Proposition

Consider the full model, extended to feature innovations $m_t$ to the central bank’s rule. The impulse responses of all real aggregates $x \in \{s, e, d, y\}$ to:

(i) a recessionary common demand shock $b^c_0 < 0$ with persistence $\rho_b$

(ii) a contractionary monetary shock $m_0 = -(1 - \rho_b)\varsigma_c b^c_0$ with persistence $\rho_m = \rho_b$

are identical:

$$\hat{x}^c_t = \hat{x}^m_t$$
Other empirical tests: uncertainty

• Second main experiment: uncertainty shocks
  Implementation as in Basu & Bundick (2017)

• Find: V- vs. Z-shape as for monetary policy
Other empirical tests

• Oil shocks
  ○ Project granular sectoral spending series on oil shock series
  ○ Find: PUD for durables/gas/transport, not for food/clothes

• Reduced-form dynamics
  ○ Estimate reduced-form VAR in all spending components
  ○ Find: services CIR 120% larger than for durables
Details on the shift-share

Proposition

Consider the baseline model with $\gamma = \zeta$ and a passive monetary rule. Let $\hat{s}_t^m$ and $\hat{e}_t^m$ denote impulse responses to a monetary shock. Then:

1. In an alternative economy with services share $\phi'$, the response of output to a common demand shock $b^c_0$ with persistence $\rho_b = \rho_m$ and $\hat{y}_0 = -1$ is

$$\hat{y}_t = - \left[ \frac{\phi'}{\phi' \hat{s}_0^m + (1 - \phi') \hat{e}_0^m} \hat{s}_t^m + \frac{1 - \phi'}{\phi' \hat{s}_0^m + (1 - \phi') \hat{e}_0^m} \hat{e}_t^m \right]$$

2. The response of output to a combination of shocks $\{b^c_0, b^s_0, b^d_0\}$ with persistence $\rho_m$ and s.t. $\{\hat{y}_0 = -1, \phi \hat{s}_0 = -\omega, (1 - \phi) \hat{e}_0 = -(1 - \omega)\}$ is

$$\hat{y}_t = - \left[ \omega \frac{\hat{s}_t^m}{\hat{s}_0^m} + (1 - \omega) \frac{\hat{e}_t^m}{\hat{e}_0^m} \right]$$
Details on structural counterfactuals

• Baseline calibration:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Source/Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preferences</td>
<td>Discount Rate</td>
<td>0.99</td>
<td>Annual Real FFR</td>
</tr>
<tr>
<td></td>
<td>Inverse EIS</td>
<td>1</td>
<td>Literature</td>
</tr>
<tr>
<td></td>
<td>Elasticity of Substitution</td>
<td>1</td>
<td>EIS</td>
</tr>
<tr>
<td></td>
<td>Durables Consumption Share</td>
<td>0.1</td>
<td>NIPA</td>
</tr>
<tr>
<td>Technology</td>
<td>Labor Substitutability</td>
<td>10</td>
<td>Literature</td>
</tr>
<tr>
<td></td>
<td>Depreciation Rate</td>
<td>0.021</td>
<td>BEA Fixed Asset</td>
</tr>
<tr>
<td></td>
<td>Wage Re-Set Probability</td>
<td>0.2</td>
<td>Literature</td>
</tr>
<tr>
<td>Policy</td>
<td>Inflation Response</td>
<td>1.5</td>
<td>Literature</td>
</tr>
<tr>
<td>Shocks</td>
<td>Demand Shock Persistence</td>
<td>0.83</td>
<td>Lubik &amp; Schorfheide (2004)</td>
</tr>
</tbody>
</table>

• We then compare CIRs for \( \{b_0^c, b_0^s, b_0^d\} \) with shares as in:
  
  (i) COVID-19 recession
  
  (ii) average post-war recession
• Same counterfactual as a function of $\rho_b$ and $\phi_{\pi}$:
• The Wicksellian equilibrium rate of interest is

\[ \hat{r}_t = (1 - \rho_b) b^c_t \]

• Can be replicated by setting

\[ \hat{r}^n_t = (1 - \rho_b) b^c_t \]
Policy with sectoral shocks

- The Wicksellian eq’m rate for two sectoral shocks satisfies

\[
\hat{r}_t(b_0^s) = -\rho_b - \zeta_s \sum_{q=0}^{t-1} \rho_b^{t-q} \vartheta^q, \quad \hat{r}_t(b_0^d) = -\rho_b + \zeta_d \sum_{q=0}^{t-1} \rho_b^{t-q} \vartheta^q
\]

where \(\{\zeta_s, \zeta_d, \varphi\}\) are all strictly positive

- Graphical illustration:
Discount factor shocks: Covid-19 v. Average CIR

Conventional discount factor shocks instead of our agg. demand shock: