Demand Composition and the Strength of Recoveries

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Christian Wolf — MIT

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This Paper

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3. Implications for **optimal monetary policy**

Related Literature

1. **Sectoral heterogeneity & business-cycle dynamics**
   - Supply-side heterogeneity: nominal rigidities, networks
     Nakamura & Steinsson (2010), Carvalho & Grassi (2019), Bigio & La'O (2020), Pasten et al. (2017), Farhi & Baqaee (2020), La'O & Tahbaz-Salehi (2020)
   - Durables: amplification, state dependence, shape
     Mankiw (1982), Caballero (1993), Erceg & Levin (2006), Barsky et al. (2007), Berger & Vavra (2015), McKay & Wieland (2021)
2. **Strength & shape recoveries**
   Fukui et al. (2018), Fernald et al. (2017), Beraja et al. (2019), Hall & Kudlyak (2020), …
3. **COVID-19 recession**
   Chetty et al. (2020), Cox et al. (2020), Guerrieri et al. (2020), …

Model

Model Sketch

- Environment: textbook NK model + multiple sectors

    1. **Representative household**: consume **durables** and **services**
    2. **Rest of the economy**

        a) Labor-only production of intermediate goods + nominal price & wage stickiness

        b) Intermediate good can be freely turned into either durables or services

        c) Nominal rate set by monetary authority

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- **Agg. risk**: shocks to agg. demand b_t^a and sectoral demand $\{b_t^d, b_t^s\}$
  Interpretation: shock/wedge to (shadow) prices of different consumption goods

Household

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

where

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

$$v(\ell; b) = e^{\varsigma_c b^a + \varsigma_s b^s + \varsigma_d b^d} \chi \frac{\ell^{1+\frac{1}{\varphi}}}{1 + \frac{1}{\varphi}}$$

[today: $\gamma = \zeta$]

- b_t^a: aggregate demand shifter (uncertainty, income risk, deleveraging, ...)
  Note: b_t^a has no real effects in flex-price eq'm = multi-sector notion of "agg. demand"
- $\{b_t^s, b_t^d\}$: sectoral demand shifters (preference changes, disease risk, ...)

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- **Budget constraint**

$$\boldsymbol{s_t} + \underbrace{[\boldsymbol{d_t} - (1-\delta)\boldsymbol{d_{t-1}}]}_{\boldsymbol{e_t}} + \boldsymbol{\varphi(\{d_{t-\ell}\}_{\ell=0}^{\infty})} + a_t = w_t \ell_t + \frac{1 + r_{t-1}^n}{1 + \pi_t} a_{t-1} + q_t$$

▸ rest of the model

The Pent-Up Demand Mechanism

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special case: no adj. costs, iid shocks, fixed prices

Q: consider $\{b_0^a, b_0^s, b_0^d\}$ s.t. $\widehat{y}_0 = -1\%$. how does the recovery differ with sectoral composition?

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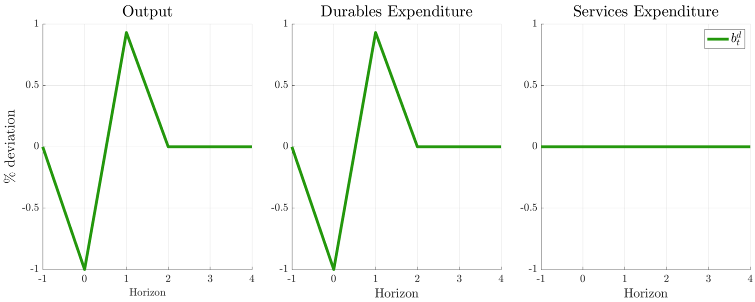

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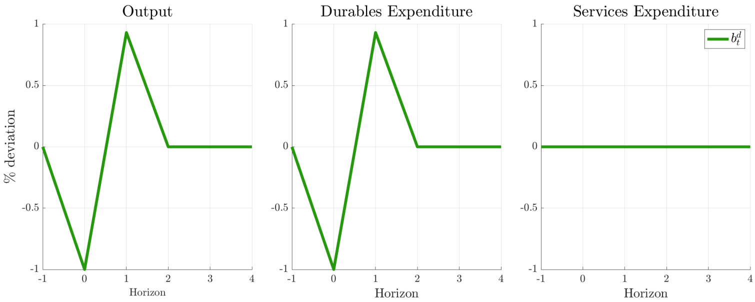

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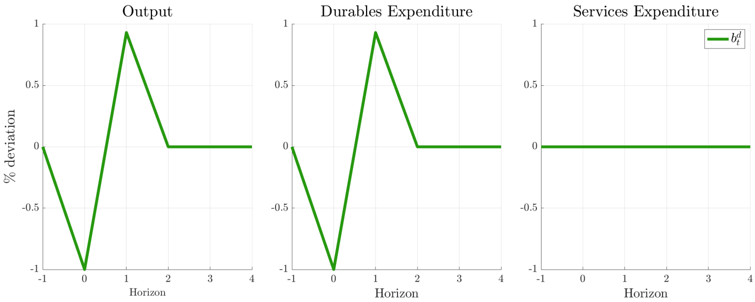

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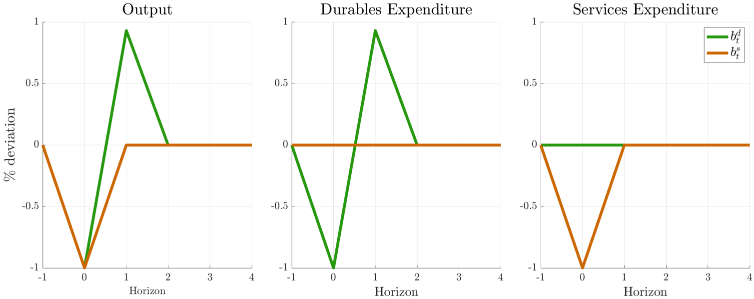

2. Services demand shock $\mathbf{b}_0^s$: no pent-up demand, lost output is foregone

$$\widehat{\mathbf{y}}^s = \frac{-1+0}{-1} = 1$$

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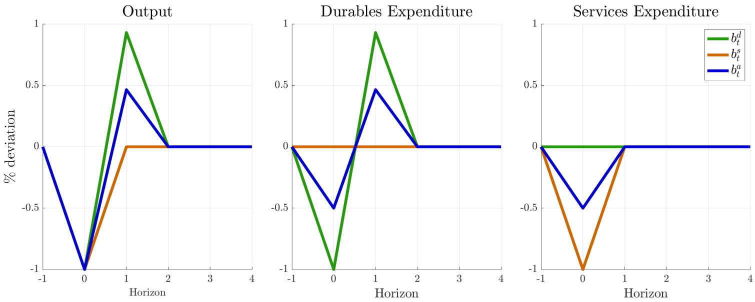

3. Aggregate demand shock $\mathbf{b}_0^a$: hybrid case

$$\widehat{\mathbf{y}}^a = 1 - \frac{1-\phi}{\phi(1-\beta(1-\delta))\delta + 1 - \phi}(1-\delta)$$

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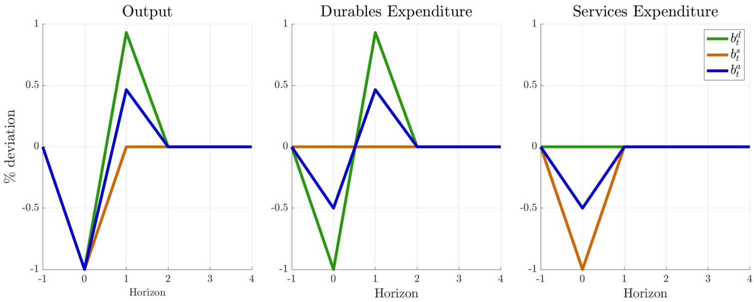

$\Rightarrow$ For any $\{\mathbf{b}_0^a, \mathbf{b}_0^s, \mathbf{b}_0^d\}$, let impact services share be $\boldsymbol{\omega} \equiv \frac{\phi \widehat{s}_0}{\phi \widehat{s}_0 + (1-\phi)\widehat{e}_0}$. Then:

$$\widehat{\mathbf{y}} = 1 - (1 - \boldsymbol{\omega})(1 - \delta)$$

Measurable Implications and Generalizations

Formal insight: **pent-up demand** $\Rightarrow$ ranking of durables and services nCIRs

Proposition

Let s^a and e^a denote the services and durables nCIRs to the aggregate demand shock $\mathbf{b}_0^a$. Then, given $\{\mathbf{b}_0^a, \mathbf{b}_0^s, \mathbf{b}_0^d\}$, $\widehat{\mathbf{y}}$ is increasing in ω if and only if

$$s^a > e^a \tag{1}$$

In words: after an aggregate demand shock b_0^a, durables revert back faster than services.

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- **Next**: measure IRFs to b^a in U.S. time series

Measurement & Quantification

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Q: How does sectoral spending respond to an agg. demand shock b^a?

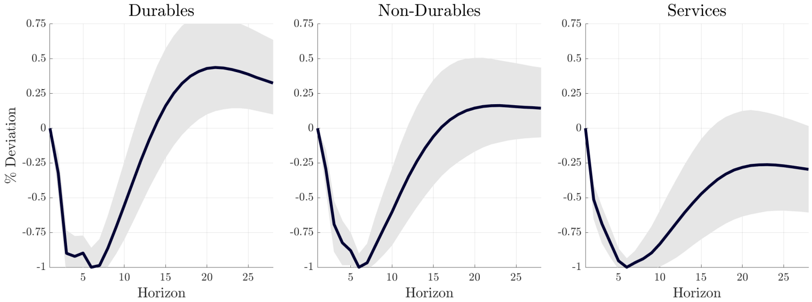
- **Ideal laboratory**: monetary policy shocks
  - Equivalent to aggregate demand shocks b_t^a ▸ Proposition
  - Relatively standard approach to time series identification is available
    Christiano-Eichenbaum-Evans (1999), Gertler-Karadi (2015), Ramey (2016), …

Today: simple recursive VAR

IRF Estimation

1. **Coarse sectoral spending dynamics**

   Echoes previous work documenting durables overshoot (Erceg-Levin, McKay-Wieland)



⇒ at posterior mode: s^c is 88% larger than e^c

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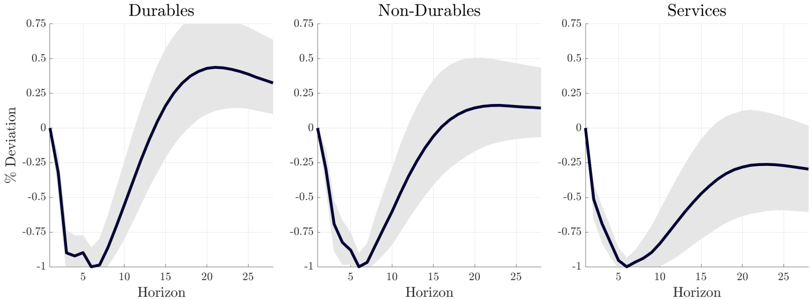

2. **Supplementary evidence**:

   ○ Granular sectors: PUD for semi-durables, little evidence of "memory goods"

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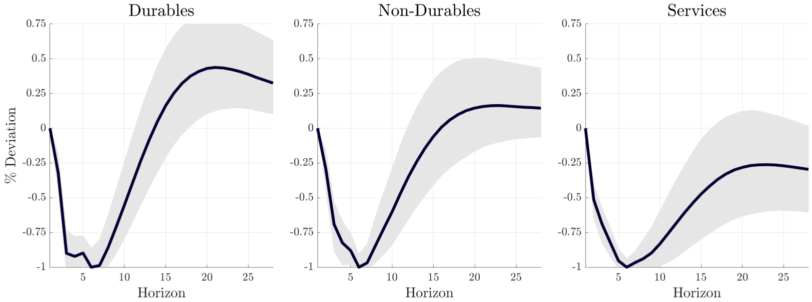

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   - Other shocks: uncertainty, oil, reduced-form innovations ▸ Details

Measurement & Quantification

How important is demand composition for recovery strength?

Counterfactual Experiments

Q: Does demand composition matter quantitatively for recovery dynamics?

(i) how different is $\boldsymbol{\omega}$ across recessions? (ii) what's the effect of that variation?

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(i) Two main reasons to expect $\boldsymbol{\omega}$ to vary across recessions:

1. Fixed agg. demand shock b_t^a, but changing long-run shares ϕ [in paper]
2. Fixed shares ϕ, but changing shock combinations $\{b_t^a, b_t^s, b_t^d\}$

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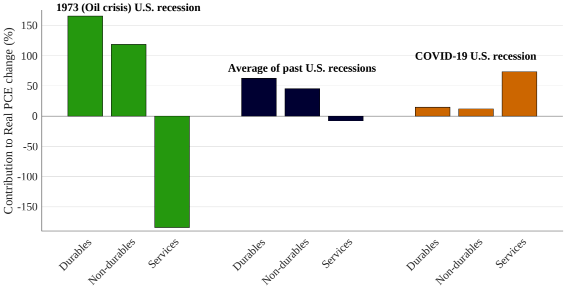

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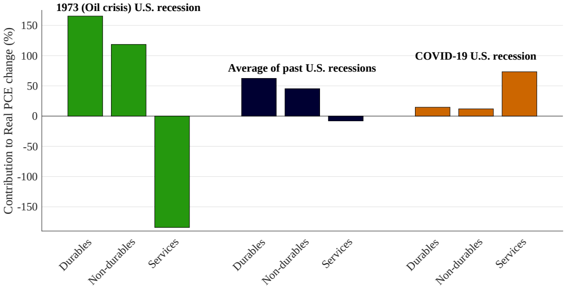

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(ii) Use estimated IRFs in two ways: 1. **shift-share** and 2. **struct. model**

Semi-Structural Shift-Share

Approach I: re-weight the empirically estimated IRFs

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Consider the full model, and suppose that monetary policy is neutral, up to monetary policy shocks with persistence ρ_m.

Then the IRF to a shock mixture $\{b_0^a, b_0^s, b_0^d\}$ with persistence ρ_m and trough services share ω satisfies

$$\widehat{y}_t = -\left[\omega \times \frac{\widehat{s}_t^m}{\widehat{s}_{trough}^m} + (1-\omega) \times \frac{\widehat{e}_t^m}{\widehat{e}_{trough}^m}\right] \quad (2)$$

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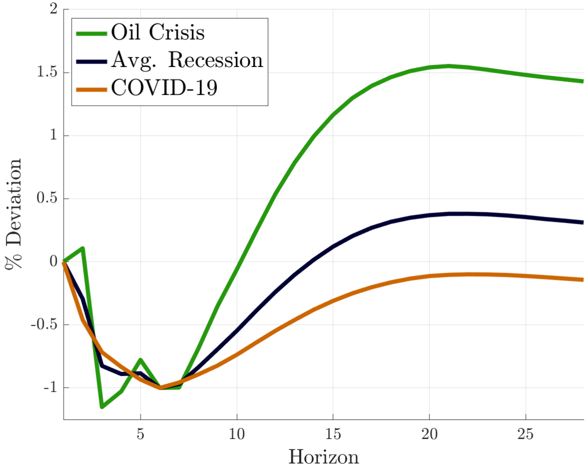
- **Model space**: relies on neutral monetary policy (or fully fixed prices)

- **Applicability**: only works for shocks as persistent as the estimated one

Results



nCIR: 65% larger for **services**-led vs. **ordinary** recession

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  - Full model: partially sticky prices & wages, conventional monetary rule
    Implies: shift-share is not exactly valid in the model
  - Addition for quantitative fit: sticky information [Mankiw-Reis]
- **Estimation**
  - IRF matching: target empirically estimated monetary policy shock IRFs
  - Why? may not be exact “sufficient statistics”, but still likely to be highly informative about our counterfactuals [Christiano-Eichenbaum-Evans]

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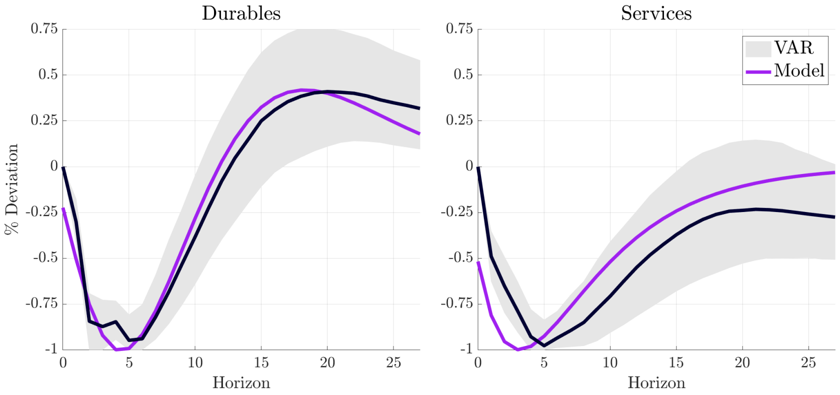
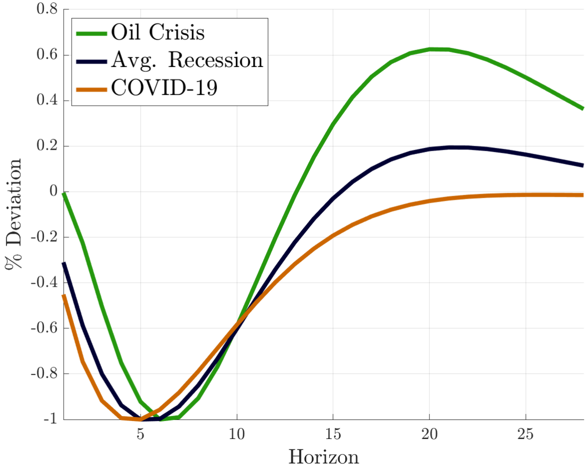
solve for counterfactuals at & around posterior mode

IRF Matching



▸ Model Parameterization

Results I



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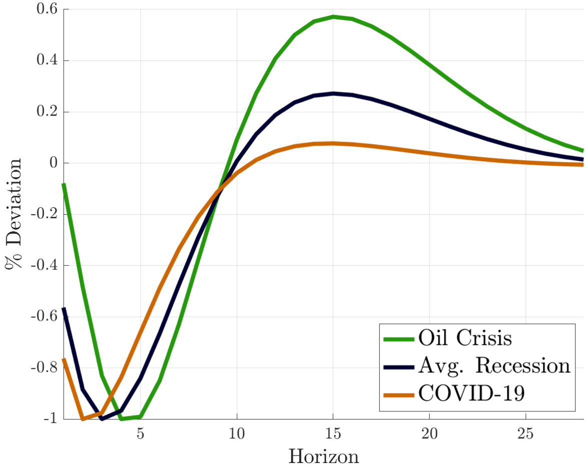
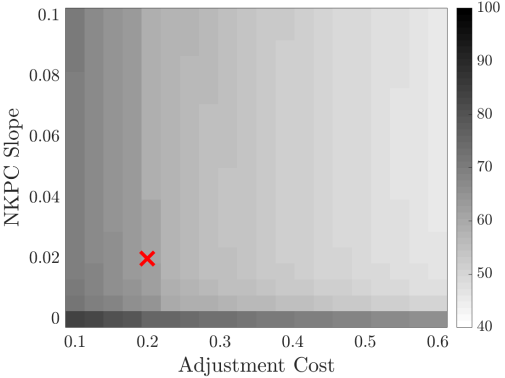
Results II: lower persistence



nCIR: 55% larger for **services**-led vs. **ordinary** recession

Results III: varying NKPC slope and adj. costs

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



robust take-away: slower recoveries for larger ω share

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

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

   - Optimal monetary policy is **independent** of services share ϕ ▸ Details
   - Intuition: transmission of both b_t^c and interest rates r_t^n are equally affected
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   - Intuition: transmission of both b_t^c and interest rates r_t^n are equally affected
   - Knife-edge result, but illustrates more general principle...

2. Fixed long-run shares with changing shock incidence $\{b_t^c, b_t^s, b_t^d\}$

   E.g.: How should central banks respond to services-led recessions?

   - **Ease for longer** if recession is biased towards services
   - Formally: fix b_0^s and b_0^d s.t. $r_0^n(b_0^s) = r_0^n(b_0^d) = -1\%$. Then: ▸ Details

$$r_t^n(b_0^s) \quad < \quad r_0^n(b_0^d), \quad \forall t \geq 2$$

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!

Rest of the Model

1. **Unions**
   - Standard wage-setting protocol gives

$$\widehat{\pi}_t^w = \frac{(1-\beta\phi_w)(1-\phi_w)}{\phi_w(\frac{\varepsilon_w}{\varphi}+1)}\left[\frac{1}{\varphi}\widehat{\ell}_t - \left(\widehat{w}_t + \widehat{\lambda}_t - (\varsigma_c b_t^c + \varsigma_s b_t^s + \varsigma_d b_t^d)\right)\right] + \beta\mathbb{E}_t\left[\widehat{\pi}_{t+1}^w\right]$$

   where λ_t is the marginal utility of wealth

2. **Producers**
   - Labor-only production and nominal rigidities give price-NKPC:

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

3. **Policy**
   - Neutral rule: $\widehat{r}_t^n = \mathbb{E}_t\left[\widehat{\pi}_{t+1}\right]$ and $\lim_{t\to\infty}\widehat{y}_t = 0$
   - Active rule

$$\widehat{r}_t^n = \phi_\pi\widehat{\pi}_t$$

back

Full Model Solution

- The sectoral spending impulse responses satisfy

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

- For aggregate output we thus get

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

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

$$\widehat{\mathbf{y}} = \frac{1}{1-\rho_b}\left[1 - (1-\omega)(1-\frac{\delta}{1-\theta_d})\right]$$

▸ back

Extensions

- **Incomplete markets**
  - A fringe μ of households has the same preferences, but is hand-to-mouth
  - Assume their income follows

$$\phi \widehat{s}_t^H + (1-\phi)\widehat{e}_t^H = \eta \widehat{y}_t$$

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

- **Supply shocks**
  - Intermediate good is turned into services at rate z_t^s and durables at rate z_t^d
  - Then supply shocks show up in two places:
    1. Prices in the household budget constraint satisfy

$$\widehat{p}_t^s = -\widehat{z}_t^s, \quad \widehat{p}_t^d = -\widehat{z}_t^d$$

    2. The output market-clearing condition becomes

$$\widehat{y}_t = \phi(-\widehat{z}_t^s + \widehat{s}_t) + (1-\phi)(-\widehat{z}_t^d + \widehat{e}_t)$$

back

Extensions

- **N sectors**
  - Household preferences over consumption bundles are now

$$u(d;b) = \frac{\left(\sum_{i=1}^{N} e^{\alpha_i (b^c + b^i)} \tilde{\phi}_i d_{it}^{1-\zeta}\right)^{\frac{1-\gamma}{1-\zeta}} - 1}{1-\gamma}$$

  - CIR satisfies

$$\widehat{\mathbf{y}} = -\sum_{i=1}^{N} \omega_i \frac{\delta_i}{1-\theta_d^i} = -\sum_{i=1}^{N} \omega_i \mathbf{e}_i^c$$

- **Sticky information**
  - Let $x \in \{c, s, d, e\}$, $p \in \{r^n, \pi, b^a, b^s, b^d\}$ and define

$$\mathcal{X}_p \equiv \frac{\partial \mathcal{X}(\bullet)}{\partial \mathbf{p}}$$

    Sticky information then modifies these derivative matrices as

$$\mathcal{X}_{p,i,j} = \sum_{s=0}^{\min\{i,j\}} [\theta^s - \theta^{s+1}] \mathcal{X}_{p,i,j}^R$$

  - Key insight: does not affect separability of the system

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Monetary Policy 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 $b_0^c < 0$ with persistence ρ_b*

(ii) *a contractionary monetary shock $m_0 = -(1 - \rho_b)\varsigma_c b_0^c$ with persistence $\rho_m = \rho_b$*

are identical:

$$\widehat{x}_t^c = \widehat{x}_t^m$$

▸ back

Fine Spending Series

Durables		Non-Durables		Services	
All	1.00	*All*	1.28	*All*	1.97
Motor Vehicles	1.14	*Food*	1.01	*Health*	1.98
Furniture	1.31	*Clothes*	0.97	*Transport*	1.65
Recreation Goods	0.86	*Gas*	1.53	*Recreation*	1.43
Other	1.19	*Other*	0.76	*Food*	2.19
				Financial	1.24
				Other	1.55

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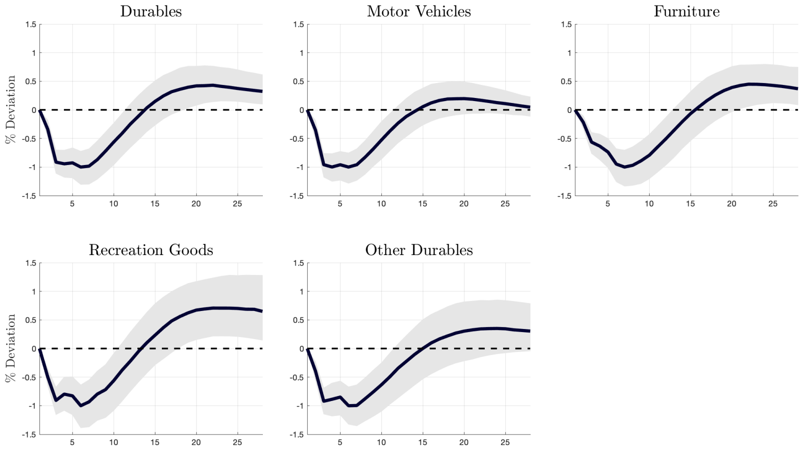
Fine Spending Series: Durables



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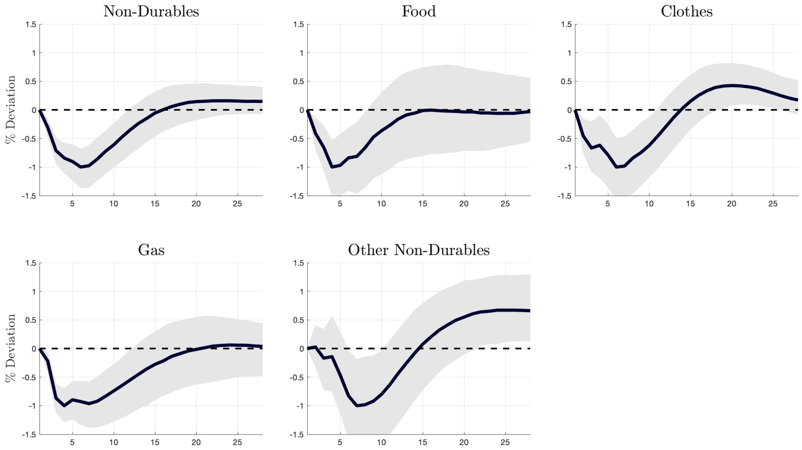
Fine Spending Series: Non-Durables



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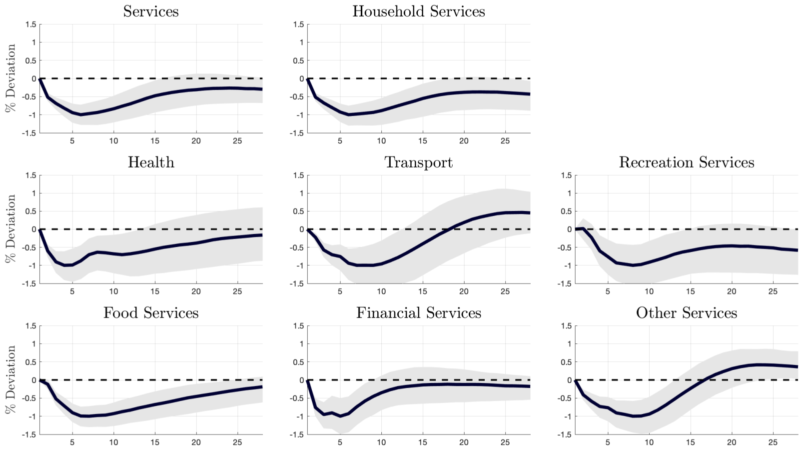
Fine Spending Series: Services



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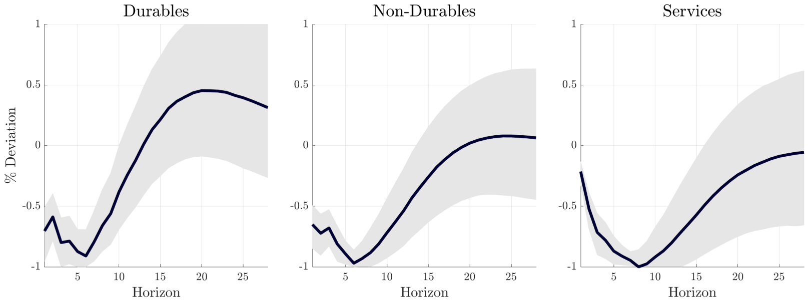
Other Shocks: Uncertainty

- Second main experiment: uncertainty shocks
  Implementation as in Basu & Bundick (2017)
- Find: V- vs. Z-shape as for monetary policy



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Other Shocks

- **Oil shocks**
  - Project granular sectoral spending series on oil shock series
    Implementation: use shock series of Hamilton (2003)
  - 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

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Estimated Model: Parameterization

Parameter	Description	Value	Source/Target
Households			
β	Discount Rate	0.99	Annual Real FFR
γ	Inverse EIS	1	Standard
ζ	Elasticity of Substitution	1	= EIS
ϕ	Durables Consumption Share	0.1	NIPA
θ	Sticky Information Friction	0.95	IRF matching
Firms & Unions			
ζ_p	Slope of the NKPC	0.02	Ajello et al. (2020)
ε_w	Labor Substitutability	10	Standard
δ	Depreciation Rate	0.021	BEA Fixed Asset
ϕ_w	Wage Re-Set Probability	0.2	Beraja et al. (2019)
κ	Level Adjustment Cost	0	IRF matching
κ_e	Flow Adjustment Cost	0.2	IRF matching
Policy			
ϕ_π	Inflation Response	1.5	Literature
Shocks			
$\rho_b = \rho_m$	Shock Persistence	0.83	Lubik & Schorfheide (2004)

Table 4.1: Baseline parameterization of the quantitative structural model.

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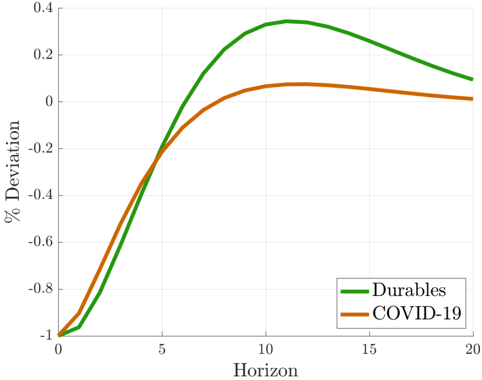
Shock Persistence

Consider a shock as transitory as **COVID-19**:



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Optimal Policy

- **Common shocks**
  - The Wicksellian equilibrium rate of interest is

$$\widehat{r}_t = (1-\rho_b)b_t^c$$

  - Can be replicated by setting

$$\widehat{r}_t^n = (1-\rho_b)b_t^c$$

- **Sectoral shocks**
  - The Wicksellian eq'm rate for two sectoral shocks satisfies

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

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

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