Demand Composition and the Strength of Recoveries

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NBER Summer Institute, July 2021
Consumer theory: pent-up demand is stronger for durables
This Paper

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
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1. **Theory**

   Multi-sector model with demand-determined output + demand shocks
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   Multi-sector model with demand-determined output + demand shocks

   Recoveries from recessions concentrated in **durables** are **stronger** than recoveries from recessions concentrated in **services**

   \[ \Leftrightarrow \]

   **durables** spending reverts faster *conditional* on aggregate demand shock (*)
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2. **Measurement**

   a) Document strong support for testable condition (*) in U.S. time series data
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2. Measurement
a) Document strong support for testable condition (*) in U.S. time series data
b) Quantify effect of demand composition on recovery strength
Use estimated IRFs + (i) semi-structural shift-share, or (ii) full structural model
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   b) Quantify effect of demand composition on recovery strength
      
      Use estimated IRFs + (i) semi-structural shift-share, or (ii) full structural model

3. Implications for **optimal monetary policy**
1. **Sectoral heterogeneity & business-cycle dynamics**
   - Supply-side heterogeneity: nominal rigidities, networks
   - Durables: amplification, state dependence, shape

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 $b^a_t$ and sectoral demand \{\(b^d_t, b^s_t\)\}

Interpretation: shock/wedge to (shadow) prices of different consumption goods
• Preferences

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

where

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

\[ \nu(\ell; b) = e^{s_c b^a + s_s b^s + s_d b^d} \frac{\ell^{1+\frac{1}{\varphi}}}{1 + \frac{1}{\varphi}} \]

[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, ...)

...
Household

- **Preferences**

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

where

\[
u(l; b) = e^{s_c b^a + s_s b^s + s_d b^d} \left[ 1 + \frac{\ell^{1+\frac{1}{\phi}}}{1 + \frac{1}{\varphi}} \right] \]

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- **Budget constraint**

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

\[
e_t
\]

rest of the model
The Pent-Up Demand Mechanism
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**special case**: no adj. costs, iid shocks, fixed prices

Q: consider \( \{b^a_0, b^s_0, b^d_0\} \) s.t. \( \hat{y}_0 = -1\% \). how does the recovery differ with sectoral composition?
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1. Durables demand shock \( b^d_0 \): recovery boosted by pent-up demand
special case: no adj. costs, iid shocks, fixed prices

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

1. Durables demand shock \( b_0^d \): recovery boosted by pent-up demand

\[
\hat{y}^d \equiv \sum_{t=0}^{\infty} \frac{\hat{y}_t^d}{\hat{y}_0^d}
\]
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1. Durables demand shock \( b^d_0 \): recovery boosted by pent-up demand

\[
\hat{y}^d = \frac{-1 + (1 - \delta)}{-1} = \delta
\]
special case: no adj. costs, iid shocks, fixed prices

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

2. Services demand shock \( b_0^s \): no pent-up demand, lost output is foregone

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

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

3. Aggregate demand shock \(b_0^a\): hybrid case

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

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

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

⇒ For any \( \{ b_0^a, b_0^s, b_0^d \} \), let impact services share be \( \omega \equiv \frac{\phi \hat{s}_0}{\phi \hat{s}_0 + (1-\phi) \hat{e}_0} \). Then:

\[
\hat{y} = 1 - (1 - \omega)(1 - \delta)
\]
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 $b^a_0$. Then, given $\{b^a_0, b^s_0, b^d_0\}$, $\hat{y}$ is increasing in $\omega$ if and only if

$$s^a > e^a$$ \hspace{1cm} (1)

In words: after an aggregate demand shock $b^a_0$, durables revert back faster than services.
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  - (i) Full model: only requires neutral monetary policy (= fix expected real rate)
    Intuition: (1) ensures that pent-up demand effects remain “strong enough”
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- **Next**: measure IRFs to $b^a$ in U.S. time series
Measurement & Quantification
Q: How does sectoral spending respond to an agg. demand shock $b^a$?

• **Ideal laboratory**: monetary policy shocks
  - Equivalent to aggregate demand shocks $b^a_t$
  - Relatively standard approach to time series identification is available

**Today**: simple recursive VAR
1. **Coarse sectoral spending dynamics**

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

⇒ at posterior mode: \( s^c \) is 88% larger than \( e^c \)
1. **Coarse sectoral spending dynamics**

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

![Graphs showing IRF for Durables, Non-Durables, and Services](image)

2. **Supplementary evidence:**

   - **Granular sectors:** PUD for semi-durables, little evidence of “memory goods”
1. **Coarse sectoral spending dynamics**

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2. **Supplementary evidence:**

   - **Granular sectors:** PUD for semi-durables, little evidence of “memory goods”

   - **Other shocks:** uncertainty, oil, reduced-form innovations
Measurement & Quantification

How important is demand composition for recovery strength?
Q: Does demand composition matter quantitatively for recovery dynamics?
   (i) how different is $\omega$ across recessions? (ii) what’s the effect of that variation?

Two main reasons to expect $\omega$ to vary across recessions:
1. Fixed agg. demand shock $b_t$, but changing long-run shares $\phi$ [in paper]
2. Fixed shares $\phi$, but changing shock combinations $\{b_t, b_s, b_d\}$

Caveat: many differences beyond demand composition (e.g., policy, shock persistence)

Use estimated IRFs in two ways: 1. shift-share and 2. struct. model
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Counterfactual Experiments

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![Graph showing contribution to Real PCE change (%)]

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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

---

Consider the full model, and suppose that monetary policy is neutral, up to monetary policy shocks with persistence $\rho_m$. Then the IRF to a shock mixture $\{b_{a0}, b_{s0}, b_{d0}\}$ with persistence $\rho_m$ and trough services share $\omega$ satisfies

$$by_t = -\omega \times bs_{m t} + (1 - \omega) \times be_{m t} + \text{(2)}$$

Construct counterfactuals semi-structurally, w/o solving a model. E.g.: no need to take a stance on relevant adjustment costs, depreciation rate, …

- Model space: relies on neutral monetary policy (or fully fixed prices)
- Applicability: only works for shocks as persistent as the estimated one
Semi-Structural Shift-Share

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

(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
nCIR: 65% larger for services-led vs. ordinary recession
Approach II: construct counterfactuals in a quantitative structural model
Structural Model

**Approach II**: construct counterfactuals in a quantitative structural model

- **Environment**
  - 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]
**Structural Model**

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solve for counterfactuals at & around posterior mode
IRF Matching

Durables

Services

% Deviation

Horizon

Model Parameterization
\textbf{nCIR}: 60\% larger for \textit{services}-led vs. \textit{ordinary} recession
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 $\omega$ share
Policy Implications
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Large effects of demand composition. Implications for **optimal policy**?
Policy Implications

Large effects of demand composition. Implications for optimal policy?

1. Aggregate demand shocks $b_t^c$ 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 $b_t^c$ and interest rates $r_t^n$ are equally affected
   - Knife-edge result, but illustrates more general principle...
Policy Implications

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   - 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
   - Formally: fix $b^s_0$ and $b^d_0$ s.t. $r^n_0(b^s_0) = r^n_0(b^d_0) = -1\%$. Then:

     $$r^n_t(b^s_0) < r^n_t(b^d_0), \quad \forall t \geq 2$$
Conclusions

basic consumer theory + demand-determined output

↓

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
     \[
     \hat{\pi}_t^w = \frac{(1 - \beta \phi_w)(1 - \phi_w)}{\phi_w \left( \frac{\varepsilon_w}{\varphi} + 1 \right)} \left[ \frac{1}{\varphi} \ell_t - \left( \hat{w}_t + \hat{\lambda}_t - (\zeta_c b_t^c + \zeta_s b_t^s + \zeta_d b_t^d) \right) \right] + \beta E_t [\hat{\pi}_{t+1}^w]
     \]
     where \( \lambda_t \) is the marginal utility of wealth.

2. **Producers**
   - Labor-only production and nominal rigidities give price-NKPC:
     \[
     \hat{\pi}_t = \zeta_p \left( \hat{w}_t - \frac{y''(\ell) \ell}{y'(\ell) \ell_t} \right) + \beta E_t [\hat{\pi}_{t+1}]
     \]

3. **Policy**
   - Neutral rule: \( \hat{r}_t^n = E_t [\hat{\pi}_{t+1}] \) and \( \lim_{t \to \infty} \hat{y}_t = 0 \)
   - Active rule
     \[
     \hat{r}_t^n = \phi \pi \hat{\pi}_t
     \]
• The sectoral spending impulse responses satisfy

\[ \hat{s}_t = \frac{1}{\gamma} (b^c_0 + b^s_0) \rho^t_b, \quad \hat{e}_t = \frac{1}{\gamma} (b^c_0 + b^d_0) \frac{\theta_b}{\delta} \left( \rho^t_b - (1 - \delta - \theta_d) \frac{\theta_d^t - \rho^t_d}{\theta_d - \rho_b} \right) \]

• For aggregate output we thus get

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

• The CIR to a generic shock mix \( \{b^c_t, b^s_t, b^d_t\} \) thus satisfies

\[ \hat{y} = \frac{1}{1 - \rho_b} \left[ 1 - (1 - \omega)(1 - \frac{\delta}{1 - \theta_d}) \right] \]
**Extensions**

- **Incomplete markets**
  - A fringe $\mu$ of households has the same preferences, but is hand-to-mouth
  - Assume their income follows
    \[ \phi \hat{s}_t^H + (1 - \phi) \hat{e}_t^H = \eta \hat{y}_t \]
    \[ \Rightarrow \text{Irrelevance result: HtMs scale IRFs up or down, but leave shapes unchanged} \]

- **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
       \[ \hat{p}_t^s = -\hat{z}_t^s, \quad \hat{p}_t^d = -\hat{z}_t^d \]
    2. The output market-clearing condition becomes
       \[ \hat{y}_t = \phi(-\hat{z}_t^s + \hat{s}_t) + (1 - \phi)(-\hat{z}_t^d + \hat{e}_t) \]
Extensions

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

• **Sticky information**
  
  ○ Let \( x \in \{c, s, d, e\} \), \( p \in \{r^n, \pi, b^a, b^s, b^d\} \) and define
    
    \[
    \chi_p \equiv \frac{\partial \chi(\bullet)}{\partial \mathbf{p}}
    \]
    
    Sticky information then modifies these derivative matrices as
    
    \[
    \chi_{p,i,j} = \sum_{s=0}^{\min\{i,j\}} [\theta^s - \theta^{s+1}] \chi_{p,i,j}^R
    \]
  
  ○ Key insight: does not affect separability of the system
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 $\rho_b$

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

are identical:

$$\hat{x}_t^c = \hat{x}_t^m$$
## Fine Spending Series

<table>
<thead>
<tr>
<th>Durables</th>
<th>Non-Durables</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>1.00</td>
<td>All</td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td>1.14</td>
<td>Food</td>
</tr>
<tr>
<td>Furniture</td>
<td>1.31</td>
<td>Clothes</td>
</tr>
<tr>
<td>Recreation Goods</td>
<td>0.86</td>
<td>Gas</td>
</tr>
<tr>
<td>Other</td>
<td>1.19</td>
<td>Other</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fine Spending Series: Durables

- Durables
- Motor Vehicles
- Furniture
- Recreation Goods
- Other Durables

% Deviation

-5
-4
-3
-2
-1
0
1
2
3
4
Fine Spending Series: Non-Durables

Non-Durables

Food

Clothes

Gas

Other Non-Durables
Fine Spending Series: Services

- Services
- Household Services
- Health
- Transport
- Recreation Services
- Food Services
- Financial Services
- Other Services
Other Shocks: Uncertainty

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

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

- **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
### Estimated Model: Parameterization

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Source/Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Households</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta$</td>
<td>Discount Rate</td>
<td>0.99</td>
<td>Annual Real FFR</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Inverse EIS</td>
<td>1</td>
<td>Standard</td>
</tr>
<tr>
<td>$\zeta$</td>
<td>Elasticity of Substitution</td>
<td>1</td>
<td>$= EIS$</td>
</tr>
<tr>
<td>$\phi$</td>
<td>Durables Consumption Share</td>
<td>0.1</td>
<td>NIPA</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Sticky Information Friction</td>
<td>0.95</td>
<td>IRF matching</td>
</tr>
<tr>
<td><strong>Firms &amp; Unions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\zeta_p$</td>
<td>Slope of the NKPC</td>
<td>0.02</td>
<td>Ajello et al. (2020)</td>
</tr>
<tr>
<td>$\varepsilon_w$</td>
<td>Labor Substitutability</td>
<td>10.0</td>
<td>Standard</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Depreciation Rate</td>
<td>0.021</td>
<td>BEA Fixed Asset</td>
</tr>
<tr>
<td>$\phi_w$</td>
<td>Wage Re-Set Probability</td>
<td>0.2</td>
<td>Beraja et al. (2019)</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>Level Adjustment Cost</td>
<td>0</td>
<td>IRF matching</td>
</tr>
<tr>
<td>$\kappa_e$</td>
<td>Flow Adjustment Cost</td>
<td>0.2</td>
<td>IRF matching</td>
</tr>
<tr>
<td><strong>Policy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\phi_\pi$</td>
<td>Inflation Response</td>
<td>1.5</td>
<td>Literature</td>
</tr>
<tr>
<td><strong>Shocks</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho_s = \rho_m$</td>
<td>Shock Persistence</td>
<td>0.83</td>
<td>Lubik &amp; Schorfheide (2004)</td>
</tr>
</tbody>
</table>

Table 4.1: Baseline parameterization of the quantitative structural model.
Shock Persistence

Consider a shock as transitory as COVID-19:
• **Common shocks**

  - The Wicksellian equilibrium rate of interest is
    \[
    \hat{r}_t = (1 - \rho_b) b_t^c
    \]
  - Can be replicated by setting
    \[
    \hat{r}_t^n = (1 - \rho_b) b_t^c
    \]

• **Sectoral shocks**

  - The Wicksellian eq’m rate for two sectoral shocks satisfies
    \[
    \hat{r}_t(b_0^s) = -\rho_b^t - \zeta_s \sum_{q=0}^{t-1} \rho_b^{t-q} \varphi^q, \quad \hat{r}_t(b_0^d) = -\rho_b^t + \zeta_d \sum_{q=0}^{t-1} \rho_b^{t-q} \varphi^q
    \]

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