SELLER’S ATTENTION IN A MULTIPRODUCT STORE

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QUESTION

How much can rational inattention help us understand variation in nominal rigidity across products and sellers?

- Models with information constraints can rationalize important features of price behavior at the micro level
- Substantial variation in nominal rigidity across products and across sellers
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- Models with information constraints can rationalize important features of price behavior at the micro level
- Substantial variation in nominal rigidity across products and across sellers

Our Contribution

- Build a tractable model of multiproduct seller to relate measures of nominal rigidity to product and seller observables
- Quantify in relationships in reduced form
- Calibrate model to quantify costs of rational inattention, state-dependence of nominal rigidity
PREVIEW OF RESULTS

Write down tractable model of rational inattention of multiproduct seller

- Generates clear measures of nominal rigidity related to attention
  - levels per regime and duration of regime

- Simple, intuitive predictions relating product observables to nominal rigidity
  - UPCs with more elastic demand, that generate more revenue, and with more volatile cost shocks should be more flexible
  - Information-constrained sellers should be less responsive to observables
PREVIEW OF RESULTS

Write down tractable model of rational inattention of multiproduct seller

- Generates clear measures of nominal rigidity related to attention
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Take the model to the data

- Substantial variation in nominal rigidity across and within UPCs

- Sellers pay attention in the way they should, but maybe not that much
  - 1 SD increase in elasticity increases regime duration by two weeks
  - Differences in observables explain 25-50% of variation across good categories

- Sellers who are likely to be more information constrained pay less attention to the observables that should matter
**Literature**

Rational Inattention and nominal rigidity

- Matejka (2010), Stevens (2013)

- Sims (1998, 2003), etc

Nominal rigidity


Multiproduct sellers

MODEL

Competitive model of consumption and pricing

- No production, no strategic interactions, no dynamics (in baseline)

Household:

- Representative household
- Nested CES demand: across stores and products (UPCs)
- Perfect attention

Seller:

- Sets prices for multiple products in store
- Faces stochastic cost shock (wholesale price)
- Information constraint
- Chooses what to learn about the shock and price as a function of acquired information
Model: Demand

Demand for a UPC \((u)\) at store \((s)\) given by

\[ C_{us} = p_{us}^{-\sigma_u} \Omega_u \]
**MODEL: SUPPLY**

Let $\kappa_{us}$ be the “attention” paid to pricing a good, the seller’s profit from a product is

$$\pi_{us}(\kappa_{us}) = \Omega_u \psi_{us}(\kappa_{us})$$
**Model: Supply**

Let $\kappa_{us}$ be the “attention” paid to pricing a good, the seller’s profit from a product is

$$\pi_{us}(\kappa_{us}) = \Omega_u \psi_{us}(\kappa_{us})$$

Define entropy as

$$H(x) = -\int h(x) \log(h(x)) \, dx.$$  

Then

$$\psi_{us}(\kappa_{us}) = \max_f(p_{us},c_{us}) \int \int (p_{us} - c_{us}) p_{us}^{-\sigma_u} f(p_{us},c_{us}) \, dp_{us} \, dc_{us}$$

s.t.

$$f(p_{us},c_{us}) \geq 0,$$

$$\int f(p_{us},c_{us}) \, dp_{us} = g(c_{us}),$$

$$H[g(c_{us})] - E_p[H[f(c_{us}|p_{us})]] \leq \kappa_{us}, \quad (\Lambda(\kappa_{us}, \sigma_u, g(c_{us})))$$
**MODEL**

Before setting a price for each product, the seller decides how much attention to pay to each product

\[
\max_{\kappa_{us}} \sum_u \pi_{us}(\kappa_{us})
\]

\[
\sum_u \kappa_{us} \leq K_s, \quad (\mu_s).
\]
MODEL

Taking the first order condition, log-linearizing, and substituting:

\[ \kappa_{us} = \beta_{us} + \beta_{us}^\Omega \log(\Omega_u) + \beta_{us}^\sigma \sigma_u + \beta_{us}^{var} \text{var}(c_u) \]

where

\[ \beta_{us} \equiv \left( \frac{\partial \log \Lambda_{us}}{\partial \kappa_{us}} \right)^{-1} (\log \mu_s - \log \Lambda_{us}) \]

\[ \beta_{us}^\Omega \equiv -\left( \frac{\partial \log \Lambda_{us}}{\partial \kappa_{us}} \right)^{-1}, \quad \text{(Demand)} \]

\[ \beta_{us}^\sigma \equiv -\left( \frac{\partial \log \Lambda_{us}}{\partial \kappa_{us}} \right)^{-1} \frac{\partial \log \Lambda_{us}}{\partial \sigma_u}, \quad \text{(Elasticity)} \]

\[ \beta_{us}^{var} \equiv -\left( \frac{\partial \log \Lambda_{us}}{\partial \kappa_{us}} \right)^{-1} \frac{\partial \log \Lambda_{us}}{\partial \text{var}(c)_u}, \quad \text{(Shock volatility)} \]

We can run the simple regression using observations on stores and UPCs

\[ \kappa_{us} = \alpha + \beta_1 \log(\Omega_u) + \beta_2 \sigma_u + \beta_3 \text{var}(c_u) + e_{us} \]
DATA AND MEASUREMENT

IRI Marketing: **prices and quantities**
- Weekly store sales at UPC level for 30 categories, 2001-2008
- 47 markets, we limit ourselves to one (San Francisco)
- 54 grocery stores

PromoData Price-Trak: **wholesale costs to retailers**
- Survey of large wholesale firms (~one per market)
- UPC-level, daily
DATA AND MEASUREMENT

UPC Elasticities: $\sigma^u$
- CES: regress expenditure shares on price changes (time differenced)
  - Fixed effects: store, date, upc X date
  - Hausman (1993) instruments: price changes in other market
- Non-linear (in progress)

UPC Demand: $\Omega_u$
- We show: $\Omega_u \propto$ revenue
- Model assumes UPC-level demand is the relevant observable
  - Revenue generated in SF market 2001-2008 in IRI data
  - Can also use share of revenue within store

UPC cost shock volatility: $c_u$
- Reported wholesale prices (including discounts, etc)
- Expected absolute price change (normalized by average price)
MEASURING REGIMES

Related to v-shaped filter ala Nakamura and Steinsson (2008), but results similar to running-mode as in Kehoe and Midrigan (2010)
**Variation in Nominal Rigidity: Categories**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levels</td>
<td>1.92</td>
<td>0.36</td>
</tr>
<tr>
<td>Length (weeks)</td>
<td>14.8</td>
<td>3.06</td>
</tr>
</tbody>
</table>
VARIATION IN REGIME DURATION ACROSS STORE-UPC

<table>
<thead>
<tr>
<th>Store-UPC</th>
<th>SD</th>
<th>12.14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share Within UPCs</td>
<td>43%</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>208,878</td>
<td></td>
</tr>
</tbody>
</table>
### Variation in Regime Levels across Store-UPC

<table>
<thead>
<tr>
<th>Store-UPC</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SD</td>
<td>0.893</td>
</tr>
<tr>
<td>Share <strong>Within</strong> UPCs</td>
<td>69%</td>
</tr>
<tr>
<td>N</td>
<td>210,996</td>
</tr>
</tbody>
</table>
**Variation in Regime Duration across UPCs**

Average Duration\(_{ucs}\) = \(\alpha + \beta_1 Elasticity_u + \beta_2 \log(Revenue_u) + \beta_3 \sigma(costs_u) + e_{ucs}\)

- **Elasticity** (\(\beta_1\))
- **Log Revenue** (\(\beta_2\))
- **Costs** (\(\beta_3\))

---

| FE  | N  | R2 |
**VARIATION IN REGIME DURATION ACROSS UPCs**

\[
\text{Average Duration}_{\text{ucs}} = \alpha_c + \beta_1 \text{Elasticity}_u + \beta_2 \log(\text{Rev}_u) + \beta_3 \sigma(\text{costs}_u) + e_{\text{ucs}}
\]

<p>| | | |</p>
<table>
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<tbody>
<tr>
<td>Elasticity ($\beta_1$)</td>
<td>-1.406***</td>
<td>(0.149)</td>
</tr>
<tr>
<td>Log Revenue ($\beta_2$)</td>
<td>-0.246</td>
<td>(0.200)</td>
</tr>
<tr>
<td>Costs ($\beta_3$)</td>
<td>-1.810***</td>
<td>(0.067)</td>
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</table>

**FE** --

N 25248
R2 0.053
**Variation in Regime Duration across UPCs**

\[ \text{Average Duration}_{ucs} = \alpha_c + \beta_1 \text{Elasticity}_u + \beta_2 \text{Log}(Rev_u) + \beta_3 \sigma(\text{costs}_u) + e_{ucs} \]

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<th>Elasticity ($\beta_1$)</th>
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<td>(0.116)</td>
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<tr>
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<td></td>
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<td>(0.070)</td>
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</table>

<table>
<thead>
<tr>
<th>FE</th>
<th>--</th>
<th>Category</th>
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<tbody>
<tr>
<td>N</td>
<td>25248</td>
<td>25248</td>
</tr>
<tr>
<td>R2</td>
<td>0.053</td>
<td>0.194</td>
</tr>
</tbody>
</table>
Variation in Regime Duration across UPCs

Average Duration_{ucs} = \alpha_c + \beta_1 Elasticity_u + \beta_2 \log(Rev_u) + \beta_3 \sigma(costs_u) + e_{ucs}

<table>
<thead>
<tr>
<th></th>
<th>\beta_1</th>
<th>\beta_2</th>
<th>\beta_3</th>
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</thead>
<tbody>
<tr>
<td>Elasticity</td>
<td>-1.406***</td>
<td>-2.126***</td>
<td>-2.017***</td>
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<tr>
<td></td>
<td>(0.149)</td>
<td>(0.116)</td>
<td>(0.115)</td>
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<tr>
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<td>-0.246</td>
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<td>-0.925***</td>
</tr>
<tr>
<td></td>
<td>(0.067)</td>
<td>(0.070)</td>
<td>(0.076)</td>
</tr>
</tbody>
</table>

FE -- Category
N 25248 25248 25248
R2 0.053 0.194 0.330
### Variation in Regime Levels Across UPCs

Average # Levels = $\alpha_c + \beta_1 Elasticity_u + \beta_2 \log(Rev_u) + \beta_3 \sigma(costs_u) + e_{uc_s}$

<table>
<thead>
<tr>
<th></th>
<th>Elasticity ($\beta_1$)</th>
<th>Log Revenue ($\beta_2$)</th>
<th>Costs ($\beta_3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.0839***</td>
<td>0.389***</td>
<td>0.0402*</td>
</tr>
<tr>
<td></td>
<td>(0.020)</td>
<td>(0.037)</td>
<td>(0.018)</td>
</tr>
<tr>
<td></td>
<td>-0.0423*</td>
<td>0.362***</td>
<td>0.0807***</td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td>(0.038)</td>
<td>(0.017)</td>
</tr>
<tr>
<td></td>
<td>-0.0229</td>
<td>0.388***</td>
<td>0.0857***</td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td>(0.041)</td>
<td>(0.019)</td>
</tr>
</tbody>
</table>

- FE: --
- N: 25248
- R2: 0.043

<table>
<thead>
<tr>
<th></th>
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<th>Category-Store</th>
</tr>
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<tbody>
<tr>
<td>N</td>
<td>25248</td>
<td>25248</td>
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<tr>
<td>R2</td>
<td>0.086</td>
<td>0.470</td>
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**Variation in Regime Duration within UPCs**

\[
\text{Average Duration}_{\text{ucs}} = \alpha_c + \beta_1 \text{Elasticity}_u + \beta_2 \text{Log}(\text{Rev}_u) + \beta_3 \sigma(\text{costs}_u) + e_{\text{ucs}}
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Variation in Regime Levels within UPCs

Average \# Levels_{ucs} = \alpha_c + \beta_1 Elasticity_u + \beta_2 \log(Rev_u) + \beta_3 \sigma(costs_u) + e_{ucs}
Conclusions and Going Forward

Conclusions:

- Product observables are related to nominal rigidity in intuitive ways
  - 25-50% of variation across product categories related to these observables
  - But economic effects appear small

- Firms that are more rigid on average are also less responsive to observables
  - Unlikely to be generated by menu costs

- Rational inattention model calibrated to these results suggest costs of inattention are small
  - Removing information capacity constraint increases profit by at most 10%
  - Likely consistent with monetary non-neutrality (speculative)

Going forward:

- Extend sample to additional markets
- Alternative demand systems
- Explore state-dependence (local employment, etc)
- Full general equilibrium model to determine macroeconomic implications