Sticky Expectations and Consumption Dynamics

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November 2007
Consumption Dynamics

Macro

- Theory: Uninsurable Risk Is Unimportant
- Evidence: Consumption Is Too Smooth
- Conclusion: Habits $\approx 0.75$

Micro

- Theory: Uninsurable Risk Is Essential
- Evidence: Habits $= 0.75$ Rejectable With Confidence $= \infty$
- $\text{var}(\Delta \log c) \approx 100 \text{ var}(\Delta \log C)$
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- Income Has Idiosyncratic And Aggregate Components
  - Idiosyncratic Component Is Perfectly Observed
  - Aggregate Component Is Stochastically Observed

Not ad hoc
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Why This Is Plausible

Idiosyncratic Variability Is $\sim 100 \times$ Bigger
- If Same Equation Estimated on Micro vs Macro Data
- Pervasive Lesson Of All Micro Data

Utility Cost Of Inattention
- Micro: Critical (and Easy) To Notice You're Unemployed
- Unlike Pischke (1995)
- Macro: Not Critical To Instantly Notice If U ↑
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- **Smoothness:** Campbell and Deaton (1989), Pischke (1995), Rotemberg and Woodford (1997)
- **Inattention:** Pischke (1995); Mankiw and Reis (2002); Reis (2003); Sims (2003)
- **Macro Habits:** Abel (1990); Constantinides (1990); many recent papers
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Total Wealth:

\[ z_{t+1} = (z_t - c_t)R + \zeta_{t+1}, \]  \hspace{1cm} (1)

Euler Equation:

\[ u'(c_t) = R\beta E_t[u'(c_{t+1})], \]  \hspace{1cm} (2)

Random Walk:

\[ \Delta c_{t+1} = \epsilon_{t+1}. \]  \hspace{1cm} (3)

Expected wealth:

\[ z_t = E_t[z_{t+1}] = E_t[z_{t+2}]... \]  \hspace{1cm} (4)
Sticky Expectations

- Consumer Who Happens To Update At $t$ and $t+n$

\[
\begin{align*}
  c_t &= (r/R)z_t \\
  c_{t+1} &= (r/R)\bar{z}_{t+1} = (r/R)z_t = c_t \\
  \vdots & \quad \vdots \\
  c_{t+n-1} &= c_t.
\end{align*}
\]

- Implies that $\Delta^n z_{t+n} \equiv z_{t+n} - z_t$ is white noise
- So individual $c$ is RW across updating periods:

\[
\begin{align*}
  c_{t+n} - c_t &= (r/R) \frac{z_{t+n} - z_t}{\Delta^n z_{t+n}} \quad (5)
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• Pop normed to one, uniformly dist on [0, 1]

\[ C_t = \int_0^1 c_{t,i} \, di. \]

• Calvo (1983) Type Updating Of Expectations:
  • Probability \( \Pi = 0.25 \)

• Economy Composed Of Many Sticky Consumers:

\[
\Delta C_{t+1} \approx (1 - \Pi) \Delta C_t + \epsilon_{t+1}
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(6)
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One More Ingredient ... 

Distinguish idiosyncratic and aggregate shocks

- Frictionless observation of idiosyncratic shocks
- True RW with respect to these
- Sticky observation of aggregate shocks

Result:

- Idiosyncratic $\Delta c$ dominated by frictionless RW part
- Aggregate $\Delta C$ highly serially correlated
- Law of large numbers: idiosyncratic part vanishes
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- All you can see is $Y$
  - Lucas: Can’t distinguish agg. from idio.
  - Muth-Pischke: Can’t distinguish tran from perm
- Here: Can see own circumstances perfectly
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- But can’t permit signal extraction wrt aggregate
  - Signal extraction wrt agg implies agg random walk
- Will return to this below

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Serious Model

Partial Equilibrium/Small Open Economy
- CRRA Utility
- Idiosyncratic Shocks Calibrated From Micro Data
- Aggregate Shocks Calibrated From Macro Data
- No Liquidity Constraints
- Mildly Impatient Consumers

DSGE Model
- Same!
Serious Model

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Income Process

- Individual’s labor productivity is

\[ \ell_{t+1} = \theta_{t+1} \Theta_{t+1} p_{t+1} P_{t+1} \equiv p_{t+1} \]  

(Id)  

- Idiosyncratic and aggregate \( p \) evolve according to

\[ p_{t+1} = p_t \psi_{t+1} \]  

(E)  

\[ P_{t+1} = P_t \Psi_{t+1} \]  

(Id)  

- \( E_t[\theta_{t+n}] = E_t[\Theta_{t+n}] = E_t[\psi_{t+n}] = E_t[\Psi_{t+n}] = 1 \ \forall \ n > 0 \)
Income Process

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- Idiosyncratic and aggregate p evolve according to
  \[
  p_{t+1} = p_t \psi_{t+1} \quad (8)
  
  P_{t+1} = P_t \Psi_{t+1} \quad (9)
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- \( E_t[\theta_{t+n}] = E_t[\Theta_{t+n}] = E_t[\psi_{t+n}] = E_t[\Psi_{t+n}] = 1 \quad \forall \ n > 0 \)
Market resources:

\[ m_{t+1} = \frac{W_{t+1}l_{t+1}}{\equiv y_{t+1}} + \frac{R_{t+1}k_{t+1}}{1+r_{t+1}} \]  

‘Assets’: Unspent resources

\[ a_t = m_t - c_t \]  

Capital transition depends on prob of survival \( \Omega \):

\[ k_{t+1} = \frac{a_t}{\Omega} \]
Market resources:

\[ m_{t+1} = W_{t+1}l_{t+1} + R_{t+1}k_{t+1} \equiv y_{t+1} + \frac{R_{t+1}k_{t+1}}{1+r_{t+1}} \] (10)

‘Assets’: Unspent resources

\[ a_t = m_t - c_t \] (11)

Capital transition depends on prob of survival \( \Omega \):

\[ k_{t+1} = \frac{a_t}{\Omega} \] (12)
Market resources:

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\begin{align*}
\mathbf{m}_{t+1} &= \mathbf{W}_{t+1} \ell_{t+1} + \mathbf{R}_{t+1} \mathbf{k}_{t+1} \\
&\equiv y_{t+1} + R_{t+1} k_{t+1} \\
\end{align*}
\]  

(10)

‘Assets’: Unspent resources

\[
\mathbf{a}_t = \mathbf{m}_t - \mathbf{c}_t
\]  

(11)

Capital transition depends on prob of survival \(\Omega\):

\[
\mathbf{k}_{t+1} = \mathbf{a}_t / \Omega
\]  

(12)
Frictionless Solution

- Assume constant $R, W$
- Normalize everything by $p_tP_t$ e.g. $m_t = m_t/p_tP_t$
- $c(m_t)$ is the function that solves

$$
v(m_t) = \max_c \{ u(c) + \beta E_t[\psi_{t+1}^{1-\rho}v(m_{t+1})] \}\]

- Level of consumption given by

$$\mathbf{c}_t = c(m_t)p_t.$$
Assume constant $\mathcal{R}, \mathcal{W}$

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- $c(m_t)$ is the function that solves
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$$v(m_t) = \max_c \{ u(c) + \beta E_t [\psi_{t+1}^{1-\rho} v(m_{t+1})] \}$$

Level of consumption given by

$$c_t = c(m_t) p_t.$$
Agent survives from $t$ to $t + 1$ with probability $\Omega$

$$p_{t+1,i} = \begin{cases} 
1 & \text{for newborns} \\
p_t,i \psi_{t+1,i} & \text{for survivors,}
\end{cases}$$

Implies steady-state distribution of $p$ with variance:

$$\text{var}(p) = \left( \frac{1 - \Omega}{1 - \Omega \mathbb{E}[\psi^2]} - 1 \right)$$
Blanchard (1985) Mortality

- Agent survives from $t$ to $t + 1$ with probability $\Omega$

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\]

- Implies steady-state distribution of $p$ with variance:

\[
\text{var}(p) = \left( \frac{1 - \Omega}{1 - \Omega E[\psi^2]} - 1 \right)
\]
\[ k_{t+1,i} = \begin{cases} 
0 & \text{if agent at } i \text{ dies, is replaced by a newborn} \\
\omega_{t+1,i} \eta / \Omega & \text{if agent at } i \text{ survives} 
\end{cases} \]

Implies

\[ K_{t+1} = \int_0^1 \omega_{t+1,i} \eta \omega_t / \Omega \, di \]
\[ = \eta A_t \]
\[ K_{t+1} = \eta A_t / \psi_{t+1} \]
Sticky Aggregate Expectations

\[ \Theta_{t,i} = \begin{cases} \Theta_t & \text{for updaters} \\ 1 & \text{for nonupdaters} \end{cases} \]

\[ \bar{P}_{t+1,i} = \pi_{t+1,i}P_{t+1} + (1 - \pi_{t+1,i})\bar{P}_{t,i} \]  

(13)

Sequence within period:

1. Shocks are Realized
2. Each Individual Updates (Or Not)
3. Consume Based on Beliefs
4. Consumer Sees End-Of-Period Bank Balance
Sticky Aggregate Expectations

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\[ \bar{P}_{t+1,i} = \pi_{t+1,i} P_{t+1} + (1 - \pi_{t+1,i}) \bar{P}_{t,i} \quad (13) \]

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(13)

Sequence within period:

1. Shocks are Realized
2. Each Individual Updates (Or Not)
3. Consume Based on Beliefs
4. Consumer Sees End-Of-Period Bank Balance
Consumers behave according to frictionless consumption function:

\[ \bar{c}_{t,i} = c(\bar{m}_{t,i}) \]
\[ c_{t,i} = \bar{c}_{t,i} \bar{P}_{t,i} p_{t,i} \]

Correctly perceive level of spending

\[ \bar{a}_{t,i} = \bar{m}_{t,i} - c_{t,i} \]  \hspace{1cm} (14)

\[ \bar{k}_{t+1,i} = \omega_{t+1,i} \bar{a}_{t,i}(a_{t,i} \pi_{t+1,i} + \bar{a}_{t,i}(1 - \pi_{t+1,i})) / \Omega + (1 - \omega_{t+1,i}) \]  \hspace{1cm} (15)
Cost Of Stickiness

Newborns’ value can be approximated by

\[ \bar{v}(W) \approx \hat{v}(W) - (\kappa/\Pi)\sigma^2_\Psi. \]  \hspace{1cm} (16)

If Newborns Pick Optimal \( \Pi \), they solve

\[ \max_{\Pi} \hat{v}(W) - (\kappa/\Pi)\sigma^2_\Psi - \iota \Pi. \]  \hspace{1cm} (17)

Solution:

\[ \Pi = (\kappa/\iota)^{0.5} \sigma_\Psi \]  \hspace{1cm} (18)
\[ P_{t+1} = \Pi P_t + (1 - \Pi) \bar{P}_t \]  

(19)

- Observe \( Y \)
- Define signal-to-noise ratio \( \varphi = \frac{\sigma^2_\psi}{\sigma^2_\theta} \)

Optimal Estimate of \( P \) obtained from

\[ \bar{P}_{t+1} = \Pi Y_{t+1} + (1 - \Pi) \bar{P}_t \]  

(20)

where

\[ \Pi = \left( \frac{1}{1 + 2/(\varphi + \sqrt{\varphi^2 + 4\varphi})} \right), \]  

(21)
\[ \bar{P}_{t+1} = \Pi P_{t+1} + (1 - \Pi) \bar{P}_t \quad (19) \]

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\[ \Pi = \left( \frac{1}{1 + \frac{2}{\varphi + \sqrt{\varphi^2 + 4\varphi}}} \right), \quad (22) \]

Pischke (1995): This is why \( C \) is too smooth

- If we calibrate using observed micro data
  - \( \Rightarrow \Delta \log C_{t+1} \approx 0.967 \Delta \log C_t \)
  - Goes too far!
- It’s because people can’t tell agg from ind shocks
- But calibration where they \( can \) see agg \( Y \Rightarrow RW \)
- Maybe could fiddle with calibration assumptions . . .
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Comparison

\[ \Pi = \left( \frac{1}{1 + \frac{2}{\phi + \sqrt{\phi^2 + 4\phi}}} \right), \quad (22) \]

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  \[ \Rightarrow \text{Goes too far!} \]

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- But calibration where they can see agg \( Y \) ⇒ RW

- Maybe could fiddle with calibration assumptions . . .
DSGE Model

Frictionless:

- No Idiosyncratic Shocks
- Aggregate Shocks Same as PE/SOE
- Cobb-Douglas production: \( M_t = K_t + K_t^\varepsilon \Theta_t^{1-\varepsilon} \)

\[
V(M_t) = \max_{C_t} \left\{ u(c_t) + \beta E_t[\psi_{t+1}^{1-\rho} V(M_{t+1})] \right\} \\
\text{s.t.} \\
A_t = M_t - C_t \\
K_{t+1} = A_t \Psi_{t+1}^{-1} \\
M_{t+1} = R_{t+1} K_{t+1} + W_{t+1} \Theta_{t+1}.
\]
DSGE Model

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s.t.
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\]
Perception Dynamics Identical to Sticky PE/SOE

\[ \tilde{M}_t = \bar{K}_t + \bar{K}_t^{\varepsilon} \bar{\Theta}_t^{1-\varepsilon} \]

Solution: \[ C_t = C(\tilde{M}_t) \bar{P}_t \]
Sticky Expectations DSGE

- Perception Dynamics Identical to Sticky PE/SOE
- $\tilde{M}_t = \tilde{K}_t + \tilde{K}_t^\varepsilon \tilde{\Theta}_t^{1-\varepsilon}$
- Solution: $C_t = C(\tilde{M}_t)\tilde{P}_t$
Perception Dynamics Identical to Sticky PE/SOE

\[ \tilde{M}_t = \tilde{K}_t + \tilde{K}_t^\varepsilon \Theta_t^{1-\varepsilon} \]

Solution: \[ C_t = C(\tilde{M}_t) \tilde{P}_t \]
Benchmark: Random Walk

\[ \Delta \log C_{t+1} \approx \varsigma + \vartheta E_t[r_{t+1}] + \mu X_{t-1} + \epsilon_{t+1}, \quad (24) \]

and random walk means \( \mu = 0 \).

In GE, \( r \) depends on \( A \) so \( \ast \) is equivalent to:

\[ \Delta \log C_{t+1} \approx \varsigma + \alpha A_t + \mu X_{t-1} + \epsilon_{t+1} \quad (25) \]

In either case, lots of \( X_{t-1} \) were found for which \( \mu \neq 0 \).
\[ \Delta \log C_{t+1} \approx \zeta + \alpha A_t + \eta E[\Delta \log Y_{t+1}] + \epsilon_{t+1} \]  

(26)

Claims:

\begin{itemize}
  \item \( \eta \) estimates fraction of ‘rule-of-thumb’ \( C = Y \) consumers
  \item \( \eta \approx 0.5 \) robustly for U.S. and other countries
  \item No further predictability in \( \Delta \log C_{t+1} \)
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Campbell and Deaton (1989); Rotemberg and Woodford (1997); Fuhrer (2000); Sommer (2001)
Dynan (2000)/Sommer specification:

$$\Delta \log C_{t+1} \approx \varsigma + \alpha A_t + \eta E[\Delta \log Y_{t+1}] + \chi E[\Delta \log C_t] + \epsilon_{t+1}$$

Claims:
- $\eta$ no longer statistically significant
- $\chi \approx 0.75$ (Habits are huge!)
- OID tests succeed
Macro Habits

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Separable Theory:
- \( \alpha < 0 \)
- \( 0 < \eta < 1 \)
- \( \chi \approx 0 \)

Micro Evidence on Habits:
- No: Meghir and Weber (1996); Dynan (2000); Flavin and Nakagawa (2005)
- Maybe a little: Carrasco, Labeaga, and Lòpez-Salido (2005)
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<table>
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<tr>
<th></th>
<th>( \chi )</th>
<th>( \eta )</th>
<th>( \alpha )</th>
</tr>
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<tbody>
<tr>
<td><strong>Micro (Separable)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theory</td>
<td>( \approx 0 )</td>
<td>( 0 &lt; \eta &lt; 1 )</td>
<td>( &lt; 0 )</td>
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<tr>
<td>Data</td>
<td>( \approx 0 )</td>
<td>( 0 &lt; \eta &lt; 1 )</td>
<td>( &lt; 0 )</td>
</tr>
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<td><strong>Macro</strong></td>
<td></td>
<td></td>
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<tr>
<td>Theory: Separable</td>
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<td>Theory: CampMan</td>
<td>( \approx 0 )</td>
<td>( \approx 0.5 )</td>
<td>( &lt; 0 )</td>
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<tr>
<td>Theory: Habits</td>
<td>( \approx 0.75 )</td>
<td>( \approx 0 )</td>
<td>( &lt; 0 )</td>
</tr>
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</table>
Calibration—DSGE

## DSGE Model

### Calibrated Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho$</td>
<td>2.00</td>
<td>Coefficient of Relative Risk Aversion</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>0.94$^{1/4}$</td>
<td>Quarterly Depreciation Factor</td>
</tr>
<tr>
<td>$K/K^\varepsilon$</td>
<td>12</td>
<td>Perf Foresight SS Capital/Output Ratio</td>
</tr>
<tr>
<td>$\sigma_\Theta^2$</td>
<td>0.00001</td>
<td>Variance Qtrly Tran Agg Pty Shocks</td>
</tr>
<tr>
<td>$\sigma_\Psi^2$</td>
<td>0.00004</td>
<td>Variance Qtrly Perm Agg Pty Shocks</td>
</tr>
</tbody>
</table>

### Steady State Solution of Model With $\sigma_\Psi = \sigma_\Theta = 0$

<table>
<thead>
<tr>
<th>Expression</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K = 12^{1/(1-\varepsilon)}$</td>
<td>$\approx 48.55$</td>
<td>Steady State Quarterly $K/P$ Ratio</td>
</tr>
<tr>
<td>$M = K + K^\varepsilon$</td>
<td>$\approx 52.6$</td>
<td>Steady State Quarterly $M/P$ Ratio</td>
</tr>
<tr>
<td>$\mathcal{W} = (1 - \varepsilon)K^\varepsilon$</td>
<td>$\approx 2.59$</td>
<td>Quarterly Wage Rate</td>
</tr>
<tr>
<td>$\mathcal{R} = 1 + \varepsilon K^{\varepsilon-1}$</td>
<td>$= 1.03$</td>
<td>Quarterly Gross Capital Income Factor</td>
</tr>
<tr>
<td>$R = \mathcal{R} \gamma$</td>
<td>$\approx 1.014$</td>
<td>Quarterly Between-Period Interest Factor</td>
</tr>
<tr>
<td>$\beta = R^{-1}$</td>
<td>$\approx 0.986$</td>
<td>Quarterly Time Preference Factor</td>
</tr>
</tbody>
</table>
### Partial Equilibrium/Small Open Economy (PE/SOE) Model Parameters

**Calibrated Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</tr>
</thead>
<tbody>
<tr>
<td>$\sigma^2_\psi$</td>
<td>0.016</td>
<td>Variance Annual Perm Idiosyncratic Shocks (PE)</td>
</tr>
<tr>
<td>$\sigma^2_\theta$</td>
<td>0.03</td>
<td>Variance Annual Tran Idiosyncratic Shocks (PE)</td>
</tr>
<tr>
<td>$\varphi$</td>
<td>0.05</td>
<td>Quarterly Probability of Unemployment Spell</td>
</tr>
<tr>
<td>$\Pi$</td>
<td>0.25</td>
<td>Quarterly Probability of Updating Expectations</td>
</tr>
<tr>
<td>$(1 - \Omega)$</td>
<td>0.005</td>
<td>Quarterly Probability of Mortality</td>
</tr>
</tbody>
</table>

**Calculated Parameters**

\[
\beta = 0.99\Omega / E[(\psi)^{-\rho}]R
\]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.965$</td>
<td></td>
<td>Satisfies Impatience Condition: $\beta &lt; \Omega / E[(\psi)^{-\rho}]R$</td>
</tr>
<tr>
<td>$\sigma^2_\psi$</td>
<td>0.004</td>
<td>Variance Qtrly Perm Idiosyncratic Shocks (PE)</td>
</tr>
<tr>
<td>$\sigma^2_\theta$</td>
<td>0.12</td>
<td>Variance Qtrly Tran Idiosyncratic Shocks (PE)</td>
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</table>
## Equilibrium

<table>
<thead>
<tr>
<th></th>
<th>PE/SOE Economy</th>
<th></th>
<th>DSGE Economy</th>
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<tbody>
<tr>
<td></td>
<td>Frictionless</td>
<td>Sticky</td>
<td>Frictionless</td>
<td>Sticky</td>
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<tr>
<td><strong>Means</strong></td>
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<tr>
<td>$A$</td>
<td>6.594</td>
<td>6.589</td>
<td>49.621</td>
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<td>$C$</td>
<td>2.683</td>
<td>2.682</td>
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<td><strong>Standard Deviations</strong></td>
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<td>Aggregate Time Series (‘Macro’)</td>
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<tr>
<td>$\log A$</td>
<td>0.016</td>
<td>0.022</td>
<td>0.056</td>
<td>0.056</td>
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<tr>
<td>$\Delta \log C$</td>
<td>0.005</td>
<td>0.002</td>
<td>0.003</td>
<td>0.001</td>
</tr>
<tr>
<td>$\Delta \log Y$</td>
<td>0.007</td>
<td>0.002</td>
<td>0.004</td>
<td>0.002</td>
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<td>Individual Cross Sectional (‘Micro’)</td>
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<tr>
<td>$\log a$</td>
<td>1.285</td>
<td>1.285</td>
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<tr>
<td>$\log c$</td>
<td>1.212</td>
<td>1.212</td>
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<tr>
<td>$\log p$</td>
<td>1.221</td>
<td>1.221</td>
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<tr>
<td>$\log y</td>
<td>y &gt; 0$</td>
<td>0.846</td>
<td>0.846</td>
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</tr>
<tr>
<td>$\Delta \log c$</td>
<td>0.151</td>
<td>0.149</td>
<td></td>
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<tr>
<td><strong>Cost Of Stickiness</strong></td>
<td>$0.31 \times 10^{-4}$</td>
<td></td>
<td>$0.53 \times 10^{-5}$</td>
<td></td>
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</table>
\[ \Delta \log c_{t+1,i} = \varsigma + \chi \Delta \log c_{t,i} + \eta E_{t,i}[\Delta \log y_{t+1,i}] + \alpha a_{t,i} \]

<table>
<thead>
<tr>
<th>Model of Expectations</th>
<th>$\chi$</th>
<th>$\eta$</th>
<th>$\alpha$</th>
<th>$\bar{R}^2$</th>
<th>nobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frictionless</td>
<td>0.083</td>
<td>0.003</td>
<td>-0.111</td>
<td>0.007</td>
<td>76020</td>
</tr>
<tr>
<td></td>
<td>(0.077)</td>
<td>(0.004)</td>
<td>(0.052)</td>
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<tr>
<td></td>
<td>0.083</td>
<td>0.009</td>
<td>-0.059</td>
<td>0.007</td>
<td>76020</td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.024)</td>
<td></td>
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</tr>
</tbody>
</table>
Micro Theory: Sticky

\[
\Delta \log c_{t+1,i} = \varsigma + \chi \Delta \log c_{t,i} + \eta E_{t,i}[\Delta \log y_{t+1,i}] + \alpha a_{t,i}
\]

<table>
<thead>
<tr>
<th>Model of Expectations</th>
<th>(\chi)</th>
<th>(\eta)</th>
<th>(\alpha)</th>
<th>(\bar{R}^2)</th>
<th>nobs</th>
</tr>
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<tbody>
<tr>
<td>Sticky</td>
<td>0.084</td>
<td>0.003</td>
<td>-0.111</td>
<td>0.000</td>
<td>76020</td>
</tr>
<tr>
<td></td>
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<td>(0.004)</td>
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<td></td>
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<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.024)</td>
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</tbody>
</table>
DSGE Macro: Frictionless

\[ \Delta \log C_{t+1} = \varsigma + \chi \Delta E[\log C_t] + \eta E[\Delta \log Y_{t+1}] + \alpha E[A_t] \]

<table>
<thead>
<tr>
<th>Expectations: Dep Var</th>
<th>Independent Variables</th>
<th>OLS or IV</th>
<th>2nd Stage $\bar{R}^2$</th>
<th>IV F p-val</th>
<th>IV OID</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frictionless: $\Delta \log C_{t+1}$</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta \log C_t$</td>
<td>$\Delta \log Y_{t+1}$</td>
<td>$A_t$</td>
<td>OLS</td>
<td>-0.001</td>
<td></td>
</tr>
<tr>
<td>0.010 (0.032)</td>
<td>0.184 (0.050)</td>
<td>-0.0002 (0.0001)</td>
<td>OLS</td>
<td>0.010</td>
<td></td>
</tr>
<tr>
<td>-0.019 (0.027)</td>
<td>0.152 (0.052)</td>
<td>-0.0002 (0.0001)</td>
<td>IV</td>
<td>0.007</td>
<td></td>
</tr>
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</table>
\[ \Delta \log C_{t+1} = \zeta + \chi \Delta E[\log C_t] + \eta E[\Delta \log Y_{t+1}] + \alpha E[A_t] \]

<table>
<thead>
<tr>
<th>Expectations: Dep Var</th>
<th>Independent Variables</th>
<th>OLS or IV</th>
<th>2nd Stage ( R^2 )</th>
<th>IV F p-val</th>
<th>IV OID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sticky</td>
<td>( \Delta \log \tilde{C}<em>t ), ( \Delta \log \tilde{Y}</em>{t+1} ), ( \tilde{A}_t )</td>
<td>OLS</td>
<td>0.677</td>
<td></td>
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<tr>
<td>statistical results</td>
<td></td>
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<td></td>
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</tbody>
</table>

\[ \Delta \log \tilde{C}_t \]

\[ \begin{align*}
0.823 \\
(0.018)
\end{align*} \]

\[ \Delta \log \tilde{Y}_{t+1} \]

\[ \begin{align*}
0.387 & \\
(0.030) \\
0.845 & \\
(0.042)
\end{align*} \]

\[ \tilde{A}_t \]

\[ \begin{align*}
0.815 & \\
(0.025)
\end{align*} \]

\[ \begin{align*}
0.0004 & \\
(0.0000)
\end{align*} \]

\[-0.0001 & \\
(0.0000)
\]

\[ \Delta \log \tilde{C}_t \]

\[ \begin{align*}
0.750 & \\
(0.148) \\
0.065 & \\
(0.146)
\end{align*} \]

Memo: For instruments \( Z_t \), \( \Delta \log C_{t+1} = Z_t \zeta \), \( R^2 = 0.425 \)

Carroll and Slacalek

Sticky Expectations and Consumption Dynamics
**Small Open Economy: Frictionless**

\[ \Delta \log C_{t+1} = \varsigma + \chi \Delta E[\log C_t] + \eta \Delta E[\log Y_{t+1}] + \alpha E[A_t] \]

<table>
<thead>
<tr>
<th>Expectations: Dep Var</th>
<th>OLS or IV</th>
<th>2nd Stage</th>
<th>IV F p-val</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frictionless: (\Delta \log C_{t+1})</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Delta \log C_t)</td>
<td>0.022</td>
<td></td>
<td>OLS 0.000</td>
</tr>
<tr>
<td>(0.010)</td>
<td>0.028</td>
<td>IV 0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td></td>
<td>0.030</td>
</tr>
<tr>
<td>(\Delta \log Y_{t+1})</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.0004)</td>
<td>−0.0008</td>
<td>OLS 0.000</td>
<td></td>
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<tr>
<td></td>
<td>(0.016)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A_t)</td>
<td>0.019</td>
<td>IV 0.000</td>
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<tr>
<td>(0.010)</td>
<td>0.028</td>
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<tr>
<td></td>
<td>(0.016)</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>−0.0005</td>
<td>IV 0.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0004)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
\[
\Delta \log C_{t+1} = \zeta + \chi \Delta E[\log C_t] + \eta E[\Delta \log Y_{t+1}] + \alpha E[A_t]
\]

<table>
<thead>
<tr>
<th>Expectations: Dep Var</th>
<th>Independent Variables</th>
<th>OLS or IV</th>
<th>2nd Stage</th>
<th>IV F p-val</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta \log \tilde{C}_t)</td>
<td>(\Delta \log \bar{Y}_{t+1})</td>
<td>(\bar{A}_t)</td>
<td>(\bar{R}^2)</td>
<td>IV OID</td>
</tr>
<tr>
<td>0.345 (0.009)</td>
<td>0.805 (0.014)</td>
<td>OLS</td>
<td>0.121</td>
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</tr>
<tr>
<td>1.150 (0.015)</td>
<td>(0.496 (0.040))</td>
<td>(0.498 (0.028))</td>
<td>IV</td>
<td>0.363 0.000</td>
</tr>
<tr>
<td>0.352 0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>IV</td>
<td>0.352 0.000</td>
</tr>
<tr>
<td>(-0.007 (0.0005))</td>
<td>(-0.0007 (0.0005))</td>
<td>IV</td>
<td>0.375 0.000</td>
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</tr>
<tr>
<td>Memo: For instruments (Z_t), (\Delta \log C_{t+1} = Z_t \zeta), (\bar{R}^2 = 0.390)</td>
<td></td>
<td></td>
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</tbody>
</table>
### Empirical Results for U.S.

\[
\Delta \log C_{t+1} = \varsigma + \chi \Delta \log C_t + \eta E[\Delta \log Y_{t+1}] + \alpha A_t
\]

<table>
<thead>
<tr>
<th>Consumption Series</th>
<th>(\chi)</th>
<th>(\eta)</th>
<th>(\alpha)</th>
<th>Method</th>
<th>(R^2)</th>
<th>IV F p-val</th>
<th>IV OID</th>
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</thead>
<tbody>
<tr>
<td>Nondurables and Services</td>
<td>0.358*** (0.066)</td>
<td>0.577*** (0.118)</td>
<td>0.0006 (0.0006)</td>
<td>OLS 0.123</td>
<td>OLS 0.002</td>
<td>0.000 0.702</td>
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</tr>
<tr>
<td></td>
<td>0.826*** (0.147)</td>
<td>0.071 (0.118)</td>
<td>0.0000 (0.0003)</td>
<td>IV 0.143</td>
<td>IV 0.135</td>
<td>0.482</td>
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</tbody>
</table>

Memo: For instruments \(Z\), \(\Delta \log C_{t+1} = Z\varsigma\), \(R^2 = 0.168\)


Time frame: 1960Q1–2004Q3, \(\sigma^2_\psi = .0000429\), \(\sigma^2_\Theta = .0000107\)


Carrasco, Raquel, José M. Labeaga, and J. David López-Salido (2005): “Consumption and Habits: Evidence
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Carroll and Slacalek
Sticky Expectations and Consumption Dynamics


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Sommer, Martin (2001): “Habits, Sentiment and Predictable Income in the Dynamics of Aggregate Consumption,”