Pricing to Habits and the Law of One Price

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Stylized facts we wish to address

• The Law Of One Price fails at the good-by-good level even for highly traded goods.
  – Crucini and Shintani, 2006.

• A rise in government spending leads to
  – A real exchange rate depreciation.
  – An increase in private consumption.
  – A trade balance deterioration.

(Ravn, Schmitt-Grohé, and Uribe, 2007; Monacelli and Perotti, 2006; Perotti, 2006; Gali et al., 2006)
Estimation of empirical impulse responses

1. Use structural VAR to estimate effects of government purchases shocks.

\[ AX_t = B(L)X_{t-1} + u_t \]

where

\[ X_t = \begin{bmatrix}
\log g_t \\
\log y_t \\
\log c_t \\
\frac{tb_t}{yt} \\
\log e_t
\end{bmatrix} \]

2. Four lags \((L = 4)\).

3. Identification: government spending is not affected by structural innovations to any other variable than government spending itself.

4. Panel of Countries: Australia, Canada, U.K., and U.S.

5. Sample: Quarterly data from 1975 to 2005
Estimated Impulse Response Functions To A Unit Innovation in Domestic Government Purchases

Solid lines: point estimate
Dashed lines: point estimate ± 2 std
Theory

• We abstract from:
  – Nontraded goods.
  – Rule-of-thumb consumers.
  – Distribution costs.
  – Sticky prices or wages.
  – Incomplete asset markets.
  – Tariffs or quotas.
  – Nonseparabilities of preferences across consumption and leisure.
A Model of Pricing to Habits

- Two-country production economy without capital.

- Preferences
  \[ E_0 \sum_{t=0}^{\infty} \beta^t [\phi \ln(x_t) + (1 - \phi) \ln(1 - h_t)] \]

- Two traded goods: \( a \) and \( b \)

  \[ x_t = \left[ \omega x_{a,t}^{1-\frac{1}{\xi}} + (1 - \omega) x_{b,t}^{1-\frac{1}{\xi}} \right]^{1-\frac{1}{\xi}} \]
• **External deep habits** as in Ravn, Schmitt-Grohé, and Uribe (RES, 2006)

- Private Households

  Habit-adjusted consumption of good $a$

  \[
  x_{a,t}^c = \left[ \int_0^1 (c_{i,a,t} - \theta c s_{i,a,t-1}^{c})^{1-\frac{1}{\eta}} \, di \right]^{\frac{1}{1-\frac{1}{\eta}}}
  \]

  \[
  s_{i,a,t}^c = \rho s_{i,a,t-1}^c + (1 - \rho) \tilde{c}_{i,a,t}
  \]

  Habit-adjusted consumption of good $b$

  \[
  x_{b,t}^c = \left[ \int_0^1 (c_{i,b,t} - \theta c s_{i,b,t-1}^{c})^{1-\frac{1}{\eta}} \, di \right]^{\frac{1}{1-\frac{1}{\eta}}}
  \]

  \[
  s_{i,b,t}^c = \rho s_{i,b,t-1}^c + (1 - \rho) \tilde{c}_{i,b,t}
  \]

- Public sector

  \[
  x_{a,t}^g = \left[ \int_0^1 (g_{i,a,t} - \theta g s_{i,a,t-1}^{g})^{1-\frac{1}{\eta}} \, di \right]^{\frac{1}{1-\frac{1}{\eta}}}
  \]

  \[
  x_{b,t}^g = \left[ \int_0^1 (g_{i,b,t} - \theta g s_{i,b,t-1}^{g})^{1-\frac{1}{\eta}} \, di \right]^{\frac{1}{1-\frac{1}{\eta}}}
  \]
• Domestic Demand for good $a$

$$d_{i,a,t} = \left( \frac{P_{i,a,t}}{P_{a,t}} \right)^{-\eta} x_{a,t} + \theta s_{i,a,t-1}$$

Price elasticity = $-\eta \left( 1 - \theta \frac{s_{i,a,t-1}}{d_{i,a,t}} \right)$

• Foreign Demand for good $a$

$$d^*_{i,a,t} = \left( \frac{P^*_{i,a,t}}{P^*_{a,t}} \right)^{-\eta} x^*_{a,t} + \theta s^*_{i,a,t-1}$$

Price elasticity = $-\eta \left( 1 - \theta \frac{s^*_{i,a,t-1}}{d^*_{i,a,t}} \right)$
Firms

- Firms can price discriminate internationally.

- Production Function:

\[ y_{i,a,t} = h_{i,a,t} \]

- Optimal pricing

\[
P_{a,t} = \left[ 1 - \frac{1}{\eta \left( 1 - \theta \frac{d_{a,t-1}}{d_{a,t}} \right)} + \theta \Omega_{a,t} \right]^{-1} MC_t
\]

\[
P_{a,t}^* = \left[ 1 - \frac{1}{\eta \left( 1 - \theta \frac{d_{a,t-1}}{d_{a,t}} \right)} + \theta \Omega_{a,t}^* \right]^{-1} MC_t
\]

⇒ Time-varying deviation from the Law of One Price \( P_{a,t}^*/P_{a,t} \neq 1 \) and moves over time.)
## Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>0.99</td>
<td>Subjective discount factor (quarterly)</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>1</td>
<td>Intertemporal elasticity of substitution</td>
</tr>
<tr>
<td>$\phi$</td>
<td>0.15</td>
<td>Preference parameter</td>
</tr>
<tr>
<td>$\omega$</td>
<td>0.5</td>
<td>Preference parameter</td>
</tr>
<tr>
<td>$\xi$</td>
<td>1.5</td>
<td>Elasticity of substitution composite</td>
</tr>
<tr>
<td>$\eta$</td>
<td>5</td>
<td>Elasticity of substitution varieties</td>
</tr>
<tr>
<td>$s_g, s^*_q$</td>
<td>0.2</td>
<td>Government shares</td>
</tr>
</tbody>
</table>
Estimation

• Goal: Estimate deep-habit parameters:
  \[ \Theta \equiv [\theta^c \quad \theta^g \quad \rho] \]

• Strategy: Pick \( \Theta \) to minimize the distance between empirical and theoretical impulse responses.

• Match 9 quarters of impulse responses of five variables.

**Estimated Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Point Estimate</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \theta^c )</td>
<td>0.52</td>
<td>0.08</td>
</tr>
<tr>
<td>( \theta^g )</td>
<td>0.57</td>
<td>0.15</td>
</tr>
<tr>
<td>( \rho )</td>
<td>0.99</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Predicted and Estimated Impulse Responses

- $g_t$
- $c_t$
- $y_t$
- $nxy_t$
- $rer_t$

Data
Data ± 2std
Deep Habits
Response of the Domestic and Foreign Markups to a One-Percent Government Spending Shock

![Graph showing the response of domestic and foreign markups to a one-percent government spending shock. The graph plots percent deviation from trend against quarters after the shock. The domestic markup shows a significant increase, while the foreign markup remains relatively stable.](image-url)
Response of the Real Exchange Rate to a Government Spending Shock

Data +2 std
Data
Deep
Data −2 std

Percent deviation from trend

Quarters after the shock
Response of Private Consumption to a Government Spending Shock

Data

Deep

Superficial

Data +2 std

Data -2 std

Percent deviation from trend

Quarters after the shock
Response of the Real Wage to a Government Spending Shock

Percent deviation from trend

Domestic Wage

Foreign Wage

Quarters after the shock
Conclusion:

- Under Pricing to Habits there are deviations from the LOOP

- Deviations from the LOOP are time varying

- Pricing to Habits can explain why in response to a demand shock
  - the real exchange rate depreciates
  - private consumption rises
  - the trade balance deteriorates

- Estimation of the model yields: $\theta^c = 0.52$, $\theta^g = 0.57$, and $\rho = 0.99$