A Finance-Integrated New Keynesian Model

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Why do Financial Markets Move so Much?

New integrated model:

1. Work-horse small-scale New Keynesian model
2. Finance habits (Campbell and Cochrane, 1999) generate time-varying risk aversion

Contribution:
Model of monetary policy with consumption-based time-varying risk premia matching jointly

Classic asset pricing puzzles
Hump-shaped macro output responses
Stocks and bonds around monetary policy announcements

Pflueger and Rinaldi (2020)
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- **Contribution:** Model of monetary policy with consumption-based time-varying risk premia matching jointly
  - Classic asset pricing puzzles
  - Hump-shaped macro output responses
  - Stocks and bonds around monetary policy announcements
Application A: Fed Funds Effect
Bernanke and Kuttner (2005)

Consumption-based risk premia amplify stock response
Costly disinflation drives down stocks, amplified by risk premia
Learning about growth alters bond risk premium response to identified shock


Model Overview

- **Exact Euler equation:** \( x_t = f^x E_t x_{t+1} + \rho^x x_{t-1} - \psi(r_t - r_t^a) + v_{x,t} \)

- **Log-linear Phillips curve:** \( \pi_t = f^{\pi} E_t \pi_{t+1} + \rho^{\pi} \pi_{t-1} + \kappa x_t + v_{\pi,t} \)

- **Interest rate rule:** see applications

\( x_t = \) output gap, \( r_t = \) real rate, \( r_t^a = \) real rate associated with expected growth, \( \pi_t = \) inflation
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- **New**: Euler equation and Phillips curve consistent with finance habits

- Homoskedastic shocks; time-varying risk premia only from preferences
Difference habit utility (Campbell and Cochrane, 1999)

\[ U_t = \frac{(C_t - H_t)^{1-\gamma} - 1}{1 - \gamma} \]

Surplus consumption ratio

\[ S_t = \frac{C_t - H_t}{C_t} \]

Log surplus consumption ratio \( s_t = \log S_t \)

Investors risk-averse when consumption falls close to habit.
Implicit Model of Habit Dynamics

\[ s_{t+1} = (1 - \theta_0)\bar{s} + \theta_0 s_t + \theta_1 x_t + \theta_2 x_{t-1} + \lambda(s_t)\epsilon_{c,t+1} \]

\( x_t = \text{output gap} = \text{consumption minus potential} \)

- Implied habit \( \approx \) distributed lag of consumption (Campbell and Cochrane, 1999)
- \( \theta_1 < 0 \) and \( \theta_2 > 0 \): Macro Euler equation with forward- and backward-looking terms (Campbell, Pflueger, and Viceira, 2020)
  - Habit increases more with most recent consumption lag
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\[ \varepsilon_{c,t+1} = c_{t+1} - E_t c_{t+1} \]

- Non-linear \( \lambda(s_t) \) decreasing in \( s_t \) (Campbell and Cochrane, 1999)
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- Non-linear \( \lambda(s_t) \) decreasing in \( s_t \) (Campbell and Cochrane, 1999)
- Shocks amplified when close to subsistence
- Risk premia have business cycle pattern (Fama and French, 1989)
  - Risk premium for one-period consumption claim
  \[ \text{Cov}_t(-m_{t+1}, c_{t+1}) = \gamma(1 + \lambda(s_t))\sigma_c^2 \]
  - Opposite sign for safe assets that pay out in high SDF states \( \Rightarrow \) flight-to-safety
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    - Opposite sign for safe assets that pay out in high SDF states \( \Rightarrow \) flight-to-safety
- Non-linear \( \lambda(s_t) \) keeps macro dynamics log-linear
Firm Problem

- Non-market hours used for home production (Greenwood, Hercowitz, and Huffman (1988))
  - Separate wages from habit (Lettau and Uhlig (2000))

- Expected productivity growth $\Delta a_{t+1}$ and learning-by-doing (Lucas (1988))

- Optimal Calvo (1983) price-setting with indexation
Interest Rate Rule

\[ i_t = \text{smoothed Taylor rule} + v_t^* + v_{ST,t} \]
\[ v_t^* = v_{t-1}^* + v_{LT,t} \]

- \( v_{ST,t} \): traditional short-term shock to monetary policy
- \( v_{LT,t} \): nominal “Fed information effect”
- \( \rho_a \): real “Fed information effect” (Nakamura and Steinsson (2018)):
  \[ \rho_a r_t = \gamma \Delta a_{t+1} =: r_t^a \]

\( i_t \) = nominal rate, \( r_t \) = real rate, \( r_t^a \) = real rate associated with expected growth
Panel A: Calibrated Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption Growth Rate</td>
<td>$g$</td>
</tr>
<tr>
<td>Utility Curvature</td>
<td>$\gamma$</td>
</tr>
<tr>
<td>Steady-State Riskfree Rate</td>
<td>$\bar{r}$</td>
</tr>
<tr>
<td>Persistence Surplus Consumption Ratio</td>
<td>$\theta_0$</td>
</tr>
<tr>
<td>Dependence Output</td>
<td>$\theta_1$</td>
</tr>
<tr>
<td>Dependence Lagged Output</td>
<td>$\theta_2$</td>
</tr>
<tr>
<td>Smoothing Parameter Consumption</td>
<td>$\phi$</td>
</tr>
<tr>
<td>Leverage</td>
<td>$\delta$</td>
</tr>
<tr>
<td>Price Stickiness</td>
<td>$\alpha$</td>
</tr>
<tr>
<td>Capital Share of Production</td>
<td>$\tau$</td>
</tr>
<tr>
<td>Cross-Goods Substitutability</td>
<td>$\theta$</td>
</tr>
<tr>
<td>Frisch Elasticity</td>
<td>$\chi_{\frac{L}{1-L}}$</td>
</tr>
<tr>
<td>MP Coefficient Output</td>
<td>$\gamma^{x}$</td>
</tr>
<tr>
<td>MP Coefficient Inflation</td>
<td>$\gamma^{\pi}$</td>
</tr>
<tr>
<td>MP Persistence</td>
<td>$\rho^{i}$</td>
</tr>
<tr>
<td>Growth Rate Dependence</td>
<td>$\rho^{a}$</td>
</tr>
</tbody>
</table>
Macro Moments (2001Q2-2019Q2)

Blue = data (95% bootstrapped CI), Black = model

- Orthogonalized impulse responses from VAR in output gap, change in inflation, and Fed Funds minus inflation
- Additional moment: Std(10 Year - 10 Year Breakeven) = 0.26%
Parameter Values (Table 1)

<table>
<thead>
<tr>
<th>Panel B: Estimated Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Std. Demand Shock (%) $\sigma_x$</td>
<td>0.37</td>
</tr>
<tr>
<td>Std. PC Shock (%) $\sigma_\pi$</td>
<td>0.49</td>
</tr>
<tr>
<td>Std. Short-Term MP (%) $\sigma_{ST}$</td>
<td>0.37</td>
</tr>
<tr>
<td>Std. Long-Term MP (%) $\sigma_{LT}$</td>
<td>0.22</td>
</tr>
</tbody>
</table>
## Asset Prices

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stocks (Levered Consumption Claim)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equity Premium</td>
<td>6.82</td>
<td>7.41</td>
</tr>
<tr>
<td>Volatility</td>
<td>13.55</td>
<td>16.96</td>
</tr>
<tr>
<td>Sharpe Ratio</td>
<td>0.50</td>
<td>0.44</td>
</tr>
<tr>
<td><strong>10 YR Breakeven (Nominal - Real Bonds)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volatility</td>
<td>5.10</td>
<td>7.01</td>
</tr>
<tr>
<td>Breakeven-Stock Beta</td>
<td>-0.13</td>
<td>-0.23</td>
</tr>
<tr>
<td><strong>10 YR Real Bonds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volatility</td>
<td>1.56</td>
<td>6.83</td>
</tr>
<tr>
<td>Real Bond-Stock Beta</td>
<td>0.03</td>
<td>-0.08</td>
</tr>
</tbody>
</table>
Application A: Fed Funds Effect (Table 3)

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Model</th>
<th>Short Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope(Equity Returns, Fed Funds)</td>
<td>-4.32</td>
<td>-6.03</td>
<td>-6.24</td>
</tr>
<tr>
<td></td>
<td>(1.65)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk Premia</td>
<td>-2.89</td>
<td>-3.14</td>
<td></td>
</tr>
</tbody>
</table>

- Model matches large empirical response
- Half due to risk premia, similarly to Bernanke and Kuttner (2005)
<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Model</th>
<th>Short Term</th>
<th>Long Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope(Equity Returns, 10Y Breakeven)</td>
<td>7.77 (4.25)</td>
<td>6.81</td>
<td>49.37</td>
<td>6.03</td>
</tr>
<tr>
<td>Risk Neutral</td>
<td>3.68</td>
<td>28.39</td>
<td>3.18</td>
<td></td>
</tr>
</tbody>
</table>

- Long-term monetary policy shock generates costly disinflation
- Stock response amplified by risk premia
Application C: Real Fed Information Effect

- Learning about growth increases real bond yields in response to ST monetary policy shock
- Risk premia go the other way, making empirical finding more striking
Whether real bonds benefit from flight-to-safety depends on macroeconomic regime

\[ \text{Corr}(r_t, \text{growth}) > 0 \Rightarrow \text{real bonds do well in bad states} \Rightarrow \text{safer} \]

Learning about growth implies that bonds benefit more from flight-to-safety after identified monetary policy shock
Conclusion

- Make consumption-based finance habits applicable to macroeconomic models
- Parsimonious model matches both macro and asset pricing moments
- Interpret bond and stock movements around monetary policy news