Monetary Policy and the Uncovered Interest Rate Parity Puzzle

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The Global Economy

Exchange Rates
The idea

• Exchange rates…
The idea

• Exchange rates…

… where economic theory goes to die!!!
Simplest version of UIP

- cross-country nominal interest rates differences are compensation for expected currency depreciation

\[ i_t - i_t^* \approx (s_{t+1} - s_t) + \text{noise} \]

- unfortunately, most of our models make this prediction... but the data look nothing like this
US-UK 3-months
US-World 1-year

CAD, EUR, JPY, CHF, GBP
1979Q1-2011Q4

\[ y = 0.02 - 0.54x \]
What’s missing from the simple UIP story? Risk!

\[ i_t - i_t^* = f_t - s_t \]
\[ = f_t - E_t s_{t+1} + E_t s_{t+1} - s_t \]
\[ \text{risk prem} \quad \text{exp depr} \]

- Now all we need to match the data is a sensible model of the risk premium
- How easy is that? See Backus’s MBA slides.
Negative correlation?

Exchange rate movements driven by nominal pricing kernels

\[ s_{t+1} - s_t = m_{t+1}^* - m_{t+1} \]

Negative correlation between interest rate spreads and currency depreciation requires

\[ \text{Cov}(V_t m_{t+1}^* - V_t m_{t+1}, E_t m_{t+1}^* - E_t m_{t+1}) < 0 \]

and

\[ \text{Var}(V_t m_{t+1}^* - V_t m_{t+1}) > \text{Var}(E_t m_{t+1}^* - E_t m_{t+1}) \]

That’s really hard to get out of a structural model!
Question?

Does this have anything to do with monetary policy?
The model

- exchange economy with exogenous endowments
- persistent stochastic volatility of endowment growth rates
- recursive utility $\Rightarrow$ sensible asset pricing
- Taylor rule $\Rightarrow$ endogenous inflation
- 2 countries with different monetary policies
Preferences

\[ U_t = [(1 - \beta)c_t^\rho + \beta \mu_t(U_{t+1})^\rho]^{1/\rho} \]

\[ \mu_t(U_{t+1})^\alpha = E_t U_{t+1}^\alpha \]

marginal rate of intertemporal substitution

\[ n_{t+1} = \log \beta + (\rho - 1) \log (c_{t+1}/c_t) + (\alpha - \rho)[\log U_{t+1} - \log \mu_t(U_{t+1})] \]

Endowment growth with stochastic volatility

\[ x_{t+1} = (1 - \varphi_x)\theta_x + \varphi_x x_t + v_t^{1/2} \varepsilon_t^x \]

\[ \nu_{t+1} = (1 - \varphi_v)\theta_v + \varphi_v \nu_t + \sigma_v \varepsilon_t^v \]
Log-linear approximation

\[ u_t \equiv \frac{U_t}{c_t} = \left[ (1 - \beta) + \beta \mu_t \left( \frac{U_{t+1}}{c_{t+1}} \frac{c_{t+1}}{c_t} \right) \right]^{1/\rho} \]

\[ \log(u_t) \approx b_0 + b_1 \log \mu_t \]
Solution: Real pricing kernel

\[-n_{t+1} = \delta + \gamma_x x_t + \gamma_v v_t + \lambda_x v_t^{1/2} \varepsilon^x_{t+1} + \lambda_v \sigma_v \varepsilon^v_{t+1}\]

\[\gamma_x = (1 - \rho) \varphi_x \quad \gamma_v = \alpha(\alpha - \rho)(\omega_x + 1)^2/2\]

\[\lambda_x = (1 - \alpha) - (\alpha - \rho)\omega_x \quad \lambda_v = -(\alpha - \rho)\omega_v\]
Inflation

- simple Taylor rule

\[ i_t = \bar{\tau} + \tau_\pi \pi_t + \tau_x x_t \]

- could add a shock to this equation... later

- frictionless complete-markets model... TR just sets the value of the numeraire

- bond market must clear

\[ i_t = - \log E_t e^{n_{t+1}-\pi_{t+1}} \]
Equilibrium inflation

- equilibrium inflation solves

\[ \bar{\tau} + \tau_\pi \pi_t + \tau_x X_t = -\log E_t e^{\log n_{t+1} - \pi_{t+1}} \]

\[ \Rightarrow \pi_t = \frac{1}{\tau_\pi} \left[ -\bar{\tau} - \tau_x X_t - \log E_t e^{\log n_{t+1} - \pi_{t+1}} \right] \]

- note the role played by the Taylor principle: \( \tau_\pi > 1 \)

- guess solution

\[ \pi_t = a + a_x X_t + a_v V_t \]
Endogenous inflation

\[ \pi_t = a + a_x x_t + a_v v_t \]

\[ a_x = \frac{\gamma_x - \tau_x}{\tau_\pi - \phi_x} \]

\[ a_v = \frac{\gamma_v - (\lambda_x + a_x)^2 / 2}{\tau_\pi - \phi_v} \]
Nominal pricing kernel

\[-m_{t+1} = -n_{t+1} + \pi_{t+1}\]

\[= \delta + \gamma_x x_t + \gamma_v v_t + \lambda_x v_t^{1/2} \varepsilon_{t+1} + \lambda_v \sigma_v \varepsilon_{t+1}^v\]

\[\gamma_x^\$ = \gamma_x + a_x \varphi_x \quad \gamma_v^\$ = \gamma_v + a_v \varphi_v\]

\[\lambda_x^\$ = \lambda_x + a_x \quad \lambda_v^\$ = \lambda_v + a_v\]
Foreign inflation

- foreign economy has its own monetary policy summarized by a different Taylor rule

\[ i_t^* = \bar{\tau}^* + \tau_{\pi}^* \pi_t^* + \tau_x^* x_t \]

- all other parameters of the model common across the two countries (complete markets)
- solve for foreign inflation and the foreign nominal pricing kernel
- given both pricing kernels we can now talk about exchange rates
Results: theory

Risk premium on foreign currency is increasing in $\tau^*_x - \tau_x$ and decreasing in $\tau^*_\pi - \tau_\pi$

- a relatively pro-cyclical monetary policy creates a relatively risky currency
- a relatively stronger anti-inflationary monetary policy creates a relatively safer currency

Note: TR parameters also affect expected depreciation rates
Simpler example

- turn off $x_t$: $\varphi_x = 0, \tau_x = \tau_x^* = 0$

  \[ \Rightarrow a_x = a_x^* = 0 \quad a_v = \frac{\gamma_v}{\tau^*_\pi - \varphi_v} \quad a_v^* = \frac{\gamma_v}{\tau^*_\pi - \varphi_v} \]

- expected depreciation rate

  \[ E_t m^*_{t+1} - E_t m_{t+1} \approx \gamma_v^* - \gamma_v \]
  \[ = (\gamma_v + a_v) - (\gamma_v + a_v^*) \]
  \[ = a_v - a_v^* \]

- risk premium

  \[ V_t m^*_{t+1} - V_t m_{t+1} \approx (\lambda_v^*)^2 - (\lambda_v)^2 \]
  \[ = (\lambda_v + a_v^*)^2 - (\lambda_v + a_v)^2 \]
Results: quantitative (US v. Australia)
Quantitative limitations of complete markets

- under the assumption of complete markets the real exchange rate is exactly 1 and doesn’t change
- differences in the nominal pricing kernels are driven entirely by differences in the inflation processes
- choose TR parameters to match inflation moments $\Rightarrow$ exchange rate properties unrealistic
- choose TR parameters to match exchange rate moments $\Rightarrow$ inflation properties unrealistic
- Solutions? Add more shocks? Relax complete markets?
Aside: monetary policy shocks

- Add unobservable shocks to each country’s Taylor rule

\[ i_t = \bar{\tau} + \tau_\pi \pi_t + \tau_x x_t + z_t \]
\[ i_t^* = \bar{\tau}^* + \tau_\pi^* \pi_t^* + \tau_x x_t^* + z_t^* \]

- Even if policies are perfectly symmetric, these shocks will drive differences in the pricing kernels:

\[ m_{t+1}^* - m_{t+1} \approx z_{t+1}^* - z_{t+1} \]

⇒ potential for reverse engineering

- What about the nominal term structures in each country?
### Calibration

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: The Real Economy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discount factor</td>
<td>$\beta$</td>
<td>0.993</td>
</tr>
<tr>
<td>Relative risk aversion</td>
<td>$1 - \alpha$</td>
<td>90.408</td>
</tr>
<tr>
<td>Elasticity of intertemporal substitution</td>
<td>$(1 - \rho)^{-1}$</td>
<td>1.5</td>
</tr>
<tr>
<td>Mean of consumption growth</td>
<td>$\theta_x$</td>
<td>0.0015</td>
</tr>
<tr>
<td>Autocorrelation of consumption growth</td>
<td>$\varphi_x$</td>
<td>0</td>
</tr>
<tr>
<td>Cross-Country correlation in consumption innovations</td>
<td>$\eta_{x,x^*}$</td>
<td>0.999</td>
</tr>
<tr>
<td>Mean volatility level</td>
<td>$\theta_u$</td>
<td>6.165e$^{-5}$</td>
</tr>
<tr>
<td>Autocorrelation of volatility</td>
<td>$\varphi_u$</td>
<td>0.987</td>
</tr>
<tr>
<td>Volatility of volatility</td>
<td>$\sigma_u$</td>
<td>6.000e$^{-6}$</td>
</tr>
<tr>
<td>Cross-Country correlation in volatility innovations</td>
<td>$\eta_{u,u^*}$</td>
<td>0.999</td>
</tr>
<tr>
<td><strong>Panel B: The Nominal Economy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant in the domestic interest rate rule</td>
<td>$\bar{\tau}$</td>
<td>-0.002</td>
</tr>
<tr>
<td>Constant in the foreign interest rate rule</td>
<td>$\bar{\tau}^*$</td>
<td>-0.002</td>
</tr>
<tr>
<td>Domestic response to consumption growth</td>
<td>$\tau_x$</td>
<td>0.198</td>
</tr>
<tr>
<td>Foreign response to consumption growth</td>
<td>$\tau^*_x$</td>
<td>0.205</td>
</tr>
<tr>
<td>Domestic response to inflation</td>
<td>$\tau_\pi$</td>
<td>1.968</td>
</tr>
<tr>
<td>Foreign response to inflation</td>
<td>$\tau^*_\pi$</td>
<td>1.884</td>
</tr>
</tbody>
</table>
## Inflation $(\pi_t, \pi_t^*)$

**Domestic, U.S.**

<table>
<thead>
<tr>
<th></th>
<th>Model I</th>
<th>Model II</th>
<th>Model III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.833</td>
<td>2.833</td>
<td>2.834</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.911</td>
<td>0.911</td>
<td>0.914</td>
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<tr>
<td>Autocorrelation</td>
<td>0.428</td>
<td>0.898</td>
<td>0.902</td>
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<tr>
<td>Correlation$(x_t, \pi_t)$</td>
<td>-0.300</td>
<td>-0.300</td>
<td>-0.294</td>
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</tbody>
</table>

**Foreign, Australia**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.199</td>
<td>3.199</td>
<td>3.199</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.985</td>
<td>0.985</td>
<td>0.985</td>
</tr>
<tr>
<td>Autocorrelation</td>
<td>0.429</td>
<td>0.898</td>
<td>0.788</td>
</tr>
<tr>
<td>Correlation$(x_t^<em>, \pi_t^</em>)$</td>
<td>-0.300</td>
<td>-0.300</td>
<td>-0.449</td>
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</tbody>
</table>

## Nominal Interest Rate $(i_t, i_t^*)$

**Domestic, U.S.**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.304</td>
<td>3.786</td>
<td>3.773</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2.584</td>
<td>1.711</td>
<td>1.717</td>
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<tr>
<td>Autocorrelation</td>
<td>0.992</td>
<td>0.987</td>
<td>0.987</td>
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</tbody>
</table>

**Foreign, Australia**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>7.076</td>
<td>4.159</td>
<td>4.559</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.558</td>
<td>1.771</td>
<td>1.648</td>
</tr>
<tr>
<td>Autocorrelation</td>
<td>0.994</td>
<td>0.987</td>
<td>0.987</td>
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</tbody>
</table>
## Nominal Depreciation Rate (log($m^*_t/m_t$))

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Autocorrelation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.675</td>
<td>0.342</td>
<td>0.357</td>
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<tr>
<td></td>
<td>11.398</td>
<td>11.398</td>
<td>11.396</td>
</tr>
<tr>
<td></td>
<td>0.052</td>
<td>0.000</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>11.505</td>
<td></td>
<td>0.000</td>
</tr>
</tbody>
</table>

## Nominal Currency Risk Variables

<table>
<thead>
<tr>
<th></th>
<th>Nominal UIP Coefficient</th>
<th>Uncond. Risk Premium on AUD, $-E(p_t)$</th>
<th>Unconditional Sharpe Ratio</th>
<th>Conditional Risk Premium on AUD</th>
<th>Conditional Sharpe Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-1.019</td>
<td>4.459</td>
<td>0.389</td>
<td>7.933</td>
<td>0.709</td>
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<tr>
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<td>-0.127</td>
<td>0.007</td>
<td>0.001</td>
<td>0.982</td>
<td>0.084</td>
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<tr>
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<td>-1.019</td>
<td>0.421</td>
<td>0.039</td>
<td>1.080</td>
<td>0.091</td>
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<tr>
<td></td>
<td>-0.894</td>
<td>4.028</td>
<td>0.361</td>
<td>4.326</td>
<td>0.365</td>
</tr>
</tbody>
</table>
What’s next?

- Phillips curve ⇒ endogenous consumption growth
- add policy shocks disciplines by properties of nominal term structures
- more countries
- more convincing calibration/estimation