Resurrecting the Role of Real Money Balance Effects

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Motivation

• No role for money in New Keynesian models.

• Theoretical argument by Woodford (2003): central banks control interest rate and utility is separable in consumption and real money.

• Empirical support for separability:
  - Calibration by Woodford (2003)
Motivation


- **Is it really a good approximation to assume separability in consumption and real money?**
Contribution

- Structural Econometric Analysis to revisit the importance of real money balance effects.

<table>
<thead>
<tr>
<th></th>
<th>Woodford</th>
<th>Ireland</th>
<th>This paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technique</td>
<td>Calibration</td>
<td>ML</td>
<td>GMM</td>
</tr>
<tr>
<td>Definition of Money base</td>
<td>Money base</td>
<td>M2</td>
<td>M2</td>
</tr>
<tr>
<td>Structure of the economy</td>
<td>Demand block</td>
<td>Demand and supply blocks</td>
<td>Demand block</td>
</tr>
</tbody>
</table>
Main Results

• Utility is non-separable. Real money balance effects are quantitatively important.

• The degree of non-separability is lower since the beginning of the 1980´s.

• How should we interpret these results?
Important implications of my results

1. Money is not redundant.

2. Two stylized facts can be explained.

3. Optimal monetary policy changes.

4. Reduction in the degree of non-separability can account for a decrease in macroeconomic volatility.
Plan of Talk

1. Model (just log-linearized version)
2. Methodology and Econometric Specification
3. Estimates and Tests
4. Sub-sample Stability
5. Implications of my Econometric Results
6. Conclusions
1. Money in Utility Function Model

- Euler Equation (IS Curve):

\[ E_t (\hat{C}_{t+1} - \hat{C}_t) = \frac{\chi}{\sigma_c^{-1}} E_t (\hat{m}_{t+1} - \hat{m}_t) + \frac{1}{\sigma_c^{-1}} (\hat{i}_t - E_t \pi_{t+1}) + \frac{U_c \xi}{\sigma_c^{-1}} E_t (\xi_{t+1} - \xi_t) \]  \hspace{1cm} (1)

where:

\[ \hat{C}_t = \log\left(\frac{C_t}{\bar{C}}\right) \quad \hat{m}_t = \log\left(\frac{m_t}{\bar{m}}\right) \quad \hat{i}_t = \log\left(\frac{1+i_t}{1+i}\right) \quad \pi_t = \log\left(\frac{P_t}{\pi P_{t-1}}\right) \]

\[ \sigma_c = -\frac{U_c}{\bar{C} U_{cc}} \quad \chi = \frac{\bar{m} U^{mc}}{U_c} \]
1. Money in Utility Function Model

- Money Demand (LM Curve)

\[ \hat{m}_t = \eta_c \hat{C}_t - \eta_i (\hat{i}_t - \hat{i}_m) + \left[ \frac{U_{m\xi}}{U_m} - \frac{U_{c\xi}}{U_c} \right] \frac{1}{(\sigma_m^{-1} + \chi)} \xi_t \]  

(2)

where:

\[ \hat{i}_m = \log \left( \frac{1 + i_t^m}{1 + i^m} \right) \]
\[ \eta_c = \frac{\bar{v} \chi}{\Delta} + \sigma_c^{-1} \]
\[ \bar{v} = \frac{\bar{C}}{\bar{m}} \]
\[ \sigma_m^{-1} = \frac{U_m}{\bar{m}U_{mm}} \]

\[ \eta_i = \left( \frac{1 + i_t^m}{\bar{i} - i^m} \right) \frac{1}{\sigma_m^{-1} + \chi} \]
1. Money in Utility Function Model

- Money Demand Shock

\[ \xi_t = \rho_{\xi} \xi_{t-1} + \eta_t \]  (3)
2. Methodology and Econometric Specification

- GMM joint estimation of IS Curve, Money Demand and the Money Demand Shock Process.

- Two orthogonality conditions:

\[
E_t \left\{ \left[ (\hat{C}_{t+1} - \hat{C}_t) - \frac{\chi}{\sigma_c^{-1}} (\hat{m}_{t+1} - \hat{m}_t) - \frac{1}{\sigma_c^{-1}} (\hat{t}_t - \pi_{t+1}) + \frac{(1-\rho_\xi)\mu(\sigma_m^{-1} + \chi)v_t}{\sigma_c^{-1}} \right] z_t \right\} = 0 \quad (3)
\]

\[
E_t \left\{ \hat{m}_t - \eta_c \hat{C}_t + \eta_i (\hat{t}_t - \hat{t}_m) - \rho_\xi (\hat{m}_{t-1} - \eta_c \hat{C}_{t-1} + \eta_i (\hat{t}_{t-1} - \hat{t}_{m,t-1})) \right\} z_{t-1} \} = 0 \quad (4)
\]
2. Methodology and Econometric Specification

• Orthogonality condition (3) can also be written as:

\[ E_t \left\{ \hat{i}_t - \pi_{t+1} - \sigma_c^{-1}(\hat{C}_{t+1} - \hat{C}_t) + \chi(\hat{m}_{t+1} - \hat{m}_t) - (1 - \rho_x)\mu(\sigma_m^{-1} + \chi)\nu_t \right\} z_t \right\} = 0 \quad (5) \]

• Hansen and Singleton (1983) use (5) whereas Hall (1988) uses (3). Both impose \( \chi = 0 \) and they ignore Money Demand Shocks. I try both.
3. Estimates and Tests

- Consumption: Real Personal Consumption Expenditures.
- Real Money: M2 deflated by CPI.
- Price Inflation: Percentage Changes in CPI.
- Interest Rate: Three month Treasury bill rate.
- Interest Rate paid on Money: M2 own rate.

\[ \nu = 0.29 \, , \, \bar{r} = 0.0136 \, , \, \bar{r}^m = 0.0091 \]
### 3. Estimates and Tests

**Specification 1:**

<table>
<thead>
<tr>
<th></th>
<th>$\sigma_c^{-1}$</th>
<th>$\chi$</th>
<th>$\sigma_m^{-1}$</th>
<th>$\frac{\chi}{\sigma_c^{-1}}$</th>
<th>$\eta_c$</th>
<th>$\eta_i$</th>
<th>$\rho_\xi$</th>
<th>$\mu$</th>
<th>J-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Set 1</strong></td>
<td>0.816</td>
<td>0.478</td>
<td>37.272</td>
<td>0.586</td>
<td>0.850</td>
<td>5.951</td>
<td>0.964</td>
<td>-0.030</td>
<td>0.454</td>
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<td></td>
<td>(0.236)</td>
<td>(0.086)</td>
<td>(6.192)</td>
<td>(0.124)</td>
<td>(0.153)</td>
<td>(0.982)</td>
<td>(0.012)</td>
<td>(0.014)</td>
<td></td>
</tr>
<tr>
<td><strong>Set 2</strong></td>
<td>0.838</td>
<td>0.509</td>
<td>36.104</td>
<td>0.608</td>
<td>0.933</td>
<td>6.135</td>
<td>0.959</td>
<td>-0.027</td>
<td>0.253</td>
</tr>
<tr>
<td></td>
<td>(0.296)</td>
<td>(0.112)</td>
<td>(8.563)</td>
<td>(0.159)</td>
<td>(0.178)</td>
<td>(1.447)</td>
<td>(0.013)</td>
<td>(0.014)</td>
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</table>

**Specification 2:**

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<tr>
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<th>$\chi$</th>
<th>$\sigma_m^{-1}$</th>
<th>$\frac{\chi}{\sigma_c^{-1}}$</th>
<th>$\eta_c$</th>
<th>$\eta_i$</th>
<th>$\rho_\xi$</th>
<th>$\mu$</th>
<th>J-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Set 1</strong></td>
<td>1.969</td>
<td>0.746</td>
<td>30.890</td>
<td>0.379</td>
<td>1.605</td>
<td>7.100</td>
<td>0.969</td>
<td>0.070</td>
<td>0.588</td>
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<td></td>
<td>(0.329)</td>
<td>(0.158)</td>
<td>(6.366)</td>
<td>(0.060)</td>
<td>(0.183)</td>
<td>(1.459)</td>
<td>(0.013)</td>
<td>(0.049)</td>
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<tr>
<td><strong>Set 2</strong></td>
<td>1.758</td>
<td>0.577</td>
<td>23.598</td>
<td>0.329</td>
<td>1.636</td>
<td>9.292</td>
<td>0.969</td>
<td>0.086</td>
<td>0.250</td>
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<tr>
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<td>(0.331)</td>
<td>(0.136)</td>
<td>(5.703)</td>
<td>(0.073)</td>
<td>(0.226)</td>
<td>(2.235)</td>
<td>(0.014)</td>
<td>(0.069)</td>
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3. Comparison with Woodford´s estimates

<table>
<thead>
<tr>
<th></th>
<th>Woodford</th>
<th>Calibration 1</th>
<th>Calibration 2</th>
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<tbody>
<tr>
<td>Risk Aversion</td>
<td>0.16</td>
<td>0.16</td>
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<td>Chi</td>
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<td>0.49</td>
<td>0.49</td>
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<td>Income Elasticity</td>
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<td>1.00</td>
<td>1.00</td>
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<tr>
<td>Interest Semielasticity</td>
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<tr>
<td>Money Velocity</td>
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<td>0.29</td>
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<tr>
<td>Size of Real Money</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance Effects</td>
<td>0.05</td>
<td>3.05</td>
<td>0.49</td>
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4. Sub-Sample Stability

### Specification 1

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<tr>
<th></th>
<th>$\sigma_c^{-1}$</th>
<th>$\chi$</th>
<th>$\sigma_m^{-1}$</th>
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<th>$\eta_c$</th>
<th>$\eta_i$</th>
<th>$\rho_\xi$</th>
<th>$\mu$</th>
<th>J-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959:1 - 1979:4</td>
<td>0.865</td>
<td>0.732</td>
<td>45.546</td>
<td>0.847</td>
<td>1.054</td>
<td>4.854</td>
<td>0.939</td>
<td>-0.050</td>
<td>0.971</td>
</tr>
<tr>
<td></td>
<td>(0.116)</td>
<td>(0.059)</td>
<td>(3.163)</td>
<td>(0.089)</td>
<td>(0.059)</td>
<td>(0.336)</td>
<td>(0.011)</td>
<td>(0.012)</td>
<td></td>
</tr>
<tr>
<td>1980:1 - 2004:4</td>
<td>0.544</td>
<td>0.292</td>
<td>19.786</td>
<td>0.537</td>
<td>0.979</td>
<td>11.188</td>
<td>0.976</td>
<td>0.039</td>
<td>0.841</td>
</tr>
<tr>
<td></td>
<td>(0.127)</td>
<td>(0.046)</td>
<td>(2.656)</td>
<td>(0.143)</td>
<td>(0.130)</td>
<td>(1.495)</td>
<td>(0.009)</td>
<td>(0.031)</td>
<td></td>
</tr>
</tbody>
</table>

### Specification 2

<table>
<thead>
<tr>
<th></th>
<th>$\sigma_c^{-1}$</th>
<th>$\chi$</th>
<th>$\sigma_m^{-1}$</th>
<th>$\frac{\chi}{\sigma_c^{-1}}$</th>
<th>$\eta_c$</th>
<th>$\eta_i$</th>
<th>$\rho_\xi$</th>
<th>$\mu$</th>
<th>J-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959:1 - 1979:4</td>
<td>2.086</td>
<td>1.534</td>
<td>84.634</td>
<td>0.735</td>
<td>1.189</td>
<td>2.607</td>
<td>0.918</td>
<td>-0.022</td>
<td>0.972</td>
</tr>
<tr>
<td></td>
<td>(0.236)</td>
<td>(0.212)</td>
<td>(11.130)</td>
<td>(0.050)</td>
<td>(0.067)</td>
<td>(0.343)</td>
<td>(0.014)</td>
<td>(0.007)</td>
<td></td>
</tr>
<tr>
<td>1980:1 - 2004:4</td>
<td>1.809</td>
<td>0.376</td>
<td>17.236</td>
<td>0.208</td>
<td>1.500</td>
<td>12.755</td>
<td>0.978</td>
<td>0.332</td>
<td>0.875</td>
</tr>
<tr>
<td></td>
<td>(0.391)</td>
<td>(0.060)</td>
<td>(2.242)</td>
<td>(0.053)</td>
<td>(0.117)</td>
<td>(1.661)</td>
<td>(0.009)</td>
<td>(0.152)</td>
<td></td>
</tr>
</tbody>
</table>
5. Implications of my results

- Need to add AS curve, real wage equation and an interest rate rule.
- Framework: Sticky prices and flexible wages.
- Phillips curve:

\[
\pi_t - \bar{\pi} = \frac{(1 - \alpha)(1 - \alpha \beta)}{\alpha(1 + \omega \theta)} \hat{s}_t + \beta E_t (\pi_{t+1} - \bar{\pi})
\]

where:

\[
\hat{s}_t = (\omega + \sigma_c^{-1} - \eta_c \chi) \left[ x_t + \frac{\eta_i \chi}{\omega + \sigma_c^{-1} - \eta_c \chi} (\hat{i}_t - \hat{i}_m^t) \right]
\]

- Real Wage Equation:

\[
\hat{w}_t^r = \hat{w}_t^{rN} + (\omega_w + \sigma_c^{-1} - \chi \eta_c)x_t + \eta_i \chi \hat{i}_t
\]

For intuition:

\[
\frac{v_h(h_t)}{U_c(C_t, M_t / P_t)} = \frac{w_t}{P_t}
\]
5.1 Explaining Supply Side Effects

- Barth and Ramey (2001) show empirically that monetary policy can affect inflation and output also through the supply side.

- This empirical fact is usually captured by the cost channel of monetary transmission.

- The existence of real money balance effects is an alternative way to capture the supply side effects (look at AS curve).
5.2 Modestly Procyclical Real Wage response to a Monetary Policy shock

• Stylized fact: very modest response of real wages relative to the one of output after a monetary policy shock. (Altig, et al. (2004), Christiano et al. (2005))

• Most common explanation for this fact: sticky wages.

• With real money balance effects and without sticky wages, this fact can also be explained.
5.2 Modestly Procyclical Real Wage Response to a Monetary Policy Shock

\[ \chi = 0.48 \]

\[ \chi = 0.0 \]
### 5.3 Implications for Optimal Policy

**TABLE 5**

**STANDARD DEVIATIONS**

(In percentages)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Separable Utility</th>
<th>Non-Separable Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation 1/</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Output</td>
<td>2.39</td>
<td>4.20</td>
</tr>
<tr>
<td>Interest Rate 1/</td>
<td>0.47</td>
<td>0.34</td>
</tr>
<tr>
<td>Real Wage</td>
<td>2.39</td>
<td>1.95</td>
</tr>
<tr>
<td>Real Money</td>
<td>5.13</td>
<td>7.09</td>
</tr>
</tbody>
</table>

1/ Standard deviation is expressed in annual terms
5.4 Real Money Balance Effects and the Great Moderation

### TABLE 6
CHANGES IN VOLATILITY 1/

<table>
<thead>
<tr>
<th></th>
<th>Calibrated Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre 1984</td>
<td>Post 1984</td>
</tr>
<tr>
<td>Inflation</td>
<td>1.00</td>
<td>0.70</td>
</tr>
<tr>
<td>Output</td>
<td>1.00</td>
<td>0.53</td>
</tr>
</tbody>
</table>

1/ Standard deviations in the Pre 1984 period are normalized to 1.
6. Conclusions

- Utility is non-separable in consumption and real money.

- Real money balance effects are still quantitatively important but lower than they were before 1980.

- Four important implications of my results for monetary policy analysis.