A Macro-Finance model with financial factors

Hans Dewachter and Leonardo Iania

University of Leuven

Saturday 14 November 2009
Goal of the paper
2 Literature Review
3 Model
4 Estimation
5 Findings
Goal of the paper

- Improve the fit of Macro-Finance models
- Assess the impact of financial factors on the yield curve
Goal (1): Improve the fit of Macro-Finance models

- Yield Curve and Macro variables

\[ y_t(m) = A(m) + B_\pi(m)\pi_t + B_y(m) y_t + B_{icb}(m)i_{cb} \]

Macro Factors
Goal (1): Improve the fit of Macro-Finance models

A Macro-Finance model with financial factors
Goal (1): Improve the fit of Macro-Finance models

- Problem

\[ i_t^{TBill}(3m) = i_t^{cb} \]

- Solution

\[ i_t^{TBill}(3m) = i_t^{cb} + (T - Bill\ Spread) \]
Goal (2): Impact of financial factors on the yield curve

- Asses the impact of financial factors on the yield curve on the money market spreads:

\[
\text{Ted Spread} = (r_t^{Libor} - r_t^{TBill}) = (r_t^{Libor} - r_t^{Fed}) + (r_t^{Fed} - r_t^{TBill})
\]

- Introduce a return forecasting factor in a macro finance model, see Cochrane Piazzesi (AER, 2005)
Goal (2): Impact of financial factors on the yield curve

1. Across Frequencies
   - Are financial shocks important at short or long frequencies?
   - Which type of shocks is important at short (long) frequencies?

2. Across Yield Curve factors
   - Level?
   - Slope?
   - Curvature?
Presentation Outline

1. Goal of the paper
2. Literature Review
3. Model
4. Estimation
5. Findings
Ang and Piazzesi (JME 2003): macro factors explain primarily movements of the short end of the yield curve

Rudebusch and Wu (EJ 2008):
- the level factor reflects market participants’ views about the underlying inflation target of the central bank
- the slope factor captures the cyclical response of the central bank

Changes in the curvature (less obvious) related to changes in the monetary policy stance (Dewachter and Lyrio (2006))
Presentation Outline

1. Goal of the paper
2. Literature Review
3. Model
   1. Dynamics
   2. Pricing
   3. Identification
4. Model
5. Estimation
6. Findings
State Space Dynamics

- **Measurement Equation**
  \[ Y_t = A + BX_t + \Sigma \epsilon_t, \; \epsilon_t \sim N(0, I) \]

- **Transition Equation**
  \[ X_t = C + \Phi X_{t-1} + \Gamma \epsilon_t, \; \epsilon_t \sim N(0, I) \]

- **Measured Variables**
  \[ Y_t = [\pi_t, y_t, i_{cb}^t, Yields, Exp. Inflation, Libor, Eurodollar] \]

- **State Variables**
  \[ X_t = [\pi_t, y_t, i_{cb}^t, l_{1,t}, l_{2,t}, l_{3,t}, \pi_t^*, \rho_t] \]
Exponentially Affine Yield Curve Framework

\[ y_t(m) = A(m) + \]

\[ B_\pi(m)\pi_t + B_y(m) y_t + B_{icb}(m)i_{ct}^b + \]

Macro Factors

\[ B_{\pi^*}(m)\pi_t^* + B_\rho(m)\rho_t + \]

Stochastic Trends

\[ B_{l_1}(m)l_{1,t} + B_{l_2}(m)l_{2,t} + B_{l_3}(m)l_{3,t} \]

Financial Factors
Yield Pricing

- SDF

\[ M_{t+1} = \exp(-i_t - \frac{1}{2}\Lambda_t SS'\Lambda' - \Lambda'\varepsilon_{t+1}) \]

\[ \Lambda_t = \Lambda_0 + \Lambda_1 X_t \]

\[ i_t^{Bill} = \delta_0 + \delta_1 X_t \]

- No Arbitrage on the zero coupon bond

\[ p_t(m) = E_t[M_{t,t+1}p_{t+1}(m - 1)] \]

\[ p_0 = 1 \]
Factor Identifications

1. Stochastic endpoints

\[
\lim_{s \to \infty} E_t [\pi_{t+s}] = \pi_t^*
\]
\[
\lim_{s \to \infty} E_t [y_{t+s}] = 0
\]
\[
\lim_{s \to \infty} E_t [i_{t+s}^{cb}] = \pi_t^* + \rho_t
\]

2. Spread factors

\[
i_t^{Libor} - i_t^{TBill} = l_{1,t} + l_{2,t} \quad \Rightarrow \quad \text{Ted Spread}
\]
\[
i_t^{cb} - i_t^{TBill} = l_{1,t} \quad \Rightarrow \quad \text{TBill Spread}
\]
\[
i_t^{Libor} - i_t^{cb} = l_{2,t} \quad \Rightarrow \quad \text{Libor Spread}
\]

3. Return forecasting factor

\[
\Lambda_{1,(i,j)} = 0, \quad j \neq 6 \quad \Rightarrow \quad e_{ht} = A_{eh} + B_{eh}l_{3,t}
\]
Presentation Outline

1. Goal of the paper
2. Literature Review
3. Model
4. Estimation
   1. Econometrics
   2. Data-set
5. Findings
Estimation technique: Bayesian Setting

1. Find the mode of the posterior distribution (SA, Simplex Methods, NewtonRaphson)
2. Posterior Simulation via MCMC
   \[
   p(\theta_j; Z^T) \propto p(\theta_j; Z^T) p(\theta_j)
   \]
   Posterior \quad Likelihood \quad Prior
3. Target acceptance ratio 25%
4. 1000000 Iterations (50% Burn in)
5. check for convergence
Estimation technique: Data

- US quarterly data: 1960q1-2008q4
- Macroeconomic variables
  - Inflation: GDP deflator (Fred)
  - Output Gap: CBO Output Gap (CBO)
  - Policy rate: Fed fund rate (Fred)
  - Growth potential output: CBO Potential Gap (CBO)
- Yields: 3m, 6m, 1y, 3y, 5y, 10y. (Gurkaynak et al. (2006), Fred)
- Surveys on inflation expectations: 1y and 10y horizon. (Survey of professional forecast)
- Money market rates: Libor and Eurodollar (Datastream)
Presentation Outline

1. Goal of the paper
2. Literature Review
3. Model
4. Estimation
5. Findings
   1. Fit
   2. Return forecasting factor
   3. Impact of financial shocks on the yield curve
   4. Robustness check
Main Results: Summary

1. Better Fit: Outperform all macro-finance models
2. Return forecasting factor: similar to Cochrane and Piazzesi
3. Financial shocks statistically and economically impact the yield curve
4. Robustness check: out of sample, sub-sample and sensitivity analysis
Main Results

1. Better Fit, the model with financial factors:
   - outperform all macro-finance models
   - improve the fit of short term yields
   - compete with a $A_0(3)$ model

2. Return forecasting factor: similar to Cochrane and Piazzesi

3. Financial shocks statistically and economically impact the yield curve

4. Robustness check
Figure: Fit of the yield curve
### Table: Yield Curve Fit

<table>
<thead>
<tr>
<th></th>
<th>1/4 yr.</th>
<th>1/2 yr</th>
<th>1 yr.</th>
<th>3 yr.</th>
<th>5 yr.</th>
<th>10 yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ext.. MF</td>
<td>0.00*</td>
<td>0.15</td>
<td>0.21</td>
<td>0.11</td>
<td>0</td>
<td>0.23</td>
</tr>
<tr>
<td>St. MF</td>
<td>1.28</td>
<td>0.47</td>
<td>0.42</td>
<td>0.19</td>
<td>0.00*</td>
<td>0.33</td>
</tr>
<tr>
<td>Latent</td>
<td>0.14</td>
<td>0.14</td>
<td>0.16</td>
<td>0.00*</td>
<td>0.00*</td>
<td>0.16</td>
</tr>
<tr>
<td>GEW(2008)</td>
<td>-</td>
<td>-</td>
<td>0.32</td>
<td>0.17</td>
<td>0.00*</td>
<td>0.28</td>
</tr>
<tr>
<td>BCM(2006)</td>
<td>-</td>
<td>-</td>
<td>0.45</td>
<td>-</td>
<td>-</td>
<td>0.54</td>
</tr>
<tr>
<td>DL (2008)</td>
<td>-</td>
<td>-</td>
<td>0.60</td>
<td>0.58</td>
<td>0.56</td>
<td>0.54</td>
</tr>
<tr>
<td>D (2008)</td>
<td>1.03</td>
<td>0.44</td>
<td>0.40</td>
<td>0.20</td>
<td>0.08</td>
<td>0.35</td>
</tr>
</tbody>
</table>

*: Set to zero
Return Forecasting factor

1. Better Fit: Outperform all macro-finance models

2. Return forecasting factor: similar forecasting power to that of Cochrane and Piazzesi:
   - Applying the procedure of Cochrane Piazzesi (2005) we get a return forecasting factor which is correlated with our factor of .50
   - Preliminary regression analysis show that the forecasting power of our factor is similar to that of Cochrane Piazzesi (2005)

3. Financial shocks statistically and economically impact the yield curve

4. Robustness check
Figure: Return forecasting factors
Return Forecasting Factors. Correlation = 0.75

Figure: Return forecasting factors

Hans Dewachter and Leonardo Iania
Main Results

1. Better Fit: Outperform all macro-finance models
2. Return forecasting factor: similar to Cochrane and Piazzesi
3. Financial shocks statistically and economically impact the yield curve:
   - Impact yield curve at high frequencies
     - Level factor dominated by liquidity and policy rate shocks
     - Slope factor dominated by risk premia and policy shocks
     - Curvature factor dominated by liquidity and policy rate shocks
   - Impact yield curve at low frequencies
     - Level factor dominated by (i) long term inflation movements and (ii) policy rate shocks (medium frequencies)
     - Slope factor dominated by risk premia and policy shocks: risk premia shocks tend to become more important
     - Curvature factor dominated by liquidity and policy shocks
4. Robustness check
Figure: Variance decomposition

Hans Dewachter and Leonardo Iania
A Macro-Finance model with financial factors
Main Results

1. Better Fit: Outperform all macro-finance models
2. Return forecasting factor: similar to Cochrane and Piazzesi
3. Financial shocks statistically and economically impact the yield curve
   - Flight to Quality shocks reduce the level of yields, increasing the slope and curvature of the yield curve
   - Credit Crunch shocks increase the level of yields, decreasing the slope and curvature of the yield curve
   - Risk Premia shocks increase the level, slope and curvature of the yield curve
4. Robustness check
Figure: Responses to financial shocks
Main Results

1. Better Fit: Outperform all macro-finance models
2. Return forecasting factor: similar to Cochrane and Piazzesi
3. Financial shocks statistically and economically impact the yield curve
4. Robustness check
   - Sub-Sample Analysis (1986q1-2008q4) confirms the main message of the paper: financial factors play an important role in determining/explaining the movements of the level (high frequencies), slope and curvature factors
   - Out of Sample Analysis shows that the model is not overfitting
   - Sensitivity Analysis shows that the results do not depend on the priors’ specification
Figure: Variance decomposition (subsample)
Table: Out of sample forecast (1996q1-2008q4)

<table>
<thead>
<tr>
<th></th>
<th>RW</th>
<th>VAR(1)</th>
<th>DI</th>
<th>Macro</th>
<th>DI/Macro</th>
<th>DI/VAR</th>
<th>DI/RW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level</td>
<td>0.43%</td>
<td>0.56%</td>
<td>0.46%</td>
<td>0.44%</td>
<td>1.03</td>
<td>0.82</td>
<td>1.08</td>
</tr>
<tr>
<td>Slope</td>
<td>0.54%</td>
<td>0.55%</td>
<td>0.74%</td>
<td>1.03%</td>
<td>0.71</td>
<td>1.34</td>
<td>1.37</td>
</tr>
<tr>
<td>Curvature</td>
<td>0.42%</td>
<td>0.52%</td>
<td>0.93%</td>
<td>1.42%</td>
<td>0.65</td>
<td>1.78</td>
<td>2.22</td>
</tr>
<tr>
<td>Level</td>
<td>1.13%</td>
<td>1.20%</td>
<td>1.19%</td>
<td>1.14%</td>
<td>1.04</td>
<td>0.99</td>
<td>1.05</td>
</tr>
<tr>
<td>Slope</td>
<td>1.43%</td>
<td>1.34%</td>
<td>1.42%</td>
<td>1.61%</td>
<td>0.88</td>
<td>1.06</td>
<td>0.99</td>
</tr>
<tr>
<td>Curvature</td>
<td>1.19%</td>
<td>1.18%</td>
<td>1.34%</td>
<td>1.48%</td>
<td>0.91</td>
<td>1.14</td>
<td>1.13</td>
</tr>
<tr>
<td>Level</td>
<td>1.76%</td>
<td>1.75%</td>
<td>1.68%</td>
<td>1.73%</td>
<td>0.97</td>
<td>0.96</td>
<td>0.96</td>
</tr>
<tr>
<td>Slope</td>
<td>1.83%</td>
<td>1.70%</td>
<td>1.55%</td>
<td>1.93%</td>
<td>0.80</td>
<td>0.91</td>
<td>0.85</td>
</tr>
<tr>
<td>Curvature</td>
<td>1.83%</td>
<td>1.74%</td>
<td>1.54%</td>
<td>1.39%</td>
<td>1.11</td>
<td>0.89</td>
<td>0.84</td>
</tr>
<tr>
<td>Level</td>
<td>2.08%</td>
<td>2.01%</td>
<td>1.93%</td>
<td>1.98%</td>
<td>0.97</td>
<td>0.96</td>
<td>0.92</td>
</tr>
<tr>
<td>Slope</td>
<td>2.31%</td>
<td>2.19%</td>
<td>1.77%</td>
<td>1.95%</td>
<td>0.91</td>
<td>0.81</td>
<td>0.76</td>
</tr>
<tr>
<td>Curvature</td>
<td>2.31%</td>
<td>2.13%</td>
<td>1.67%</td>
<td>1.32%</td>
<td>1.26</td>
<td>0.78</td>
<td>0.72</td>
</tr>
</tbody>
</table>
Results and To-Do list

- **Results**
  1. Introducing financial factors in a Macro-Finance model helps improving the fit
  2. Financial factors clearly impact the yield curve

- **To-Do list**
  1. Determinant of the Risk premia factor
  2. Corporate Bond spreads
Grazie!