Macroeconomic Implications of Changes in the Term Premium

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Outline

1. Background and Motivation
2. Structural Analysis
3. Macro-Finance Analysis
4. Reduced-Form Analysis
5. Conclusions
Long-Term Interest Rates Very Low in 2004-5

Long-term interest rates have trended lower in recent months even as the Federal Reserve has raised the level of the target federal funds rate by 150 basis points. For the moment, the broadly unanticipated behavior of world bond markets remains a conundrum.

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Long-Term Interest Rates Very Low in 2004-5

Yield on 10-Year US Treasury Securities and Federal Funds Rate

10-year Treasury yield (right scale)
Long-Term Interest Rates Very Low in 2004-5

Yield on 10-Year US Treasury Securities and Federal Funds Rate

Federal funds rate (left scale)

10-year Treasury yield (right scale)
A significant portion of the sharp decline in the ten-year forward one-year rate over the past year appears to have resulted from a fall in term premiums.

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Term Premium Also Unusually Low in 2004-5

Kim-Wright Term Premium on 10-Year Zero-Coupon Bond

Percent
Two Questions

What are the macroeconomic implications of a change in the term premium?

How should monetary policy respond to a change in the term premium?
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The Practitioner View

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The “news” over recent months may instead be the [82 bp] run-up in the ten-year yield [over the past 3 months]… In effect, the FOMC has achieved more tightening of financial conditions over the past three months than it had on net over the entire tightening cycle.

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To the extent that the decline in forward rates can be traced to a decline in the term premium, the effect is financially stimulative and argues for greater monetary policy restraint, all else being equal. Specifically, if spending depends on long-term interest rates, special factors that lower the spread between short-term and long-term rates will stimulate aggregate demand. Thus, when the term premium declines, a higher short-term rate is required to obtain the long-term rate and the overall mix of financial conditions consistent with maximum sustainable employment and stable prices.

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Foundations of Practitioner/Chairman View Unclear

New Keynesian IS curve (linearized):

\[ y_t = \beta E_t y_{t+1} + \gamma (i_t - E_t \pi_t + 1) + \varepsilon_t \]

Solving forward:

\[ y_t = -\gamma E_t \sum_{j=0}^{\infty} \beta^j (i_{t+j} - \pi_{t+j+1}) + \varepsilon_t \]

Note: no role for the term premium in this model

Instead, practitioners' model may be more informal:

IS-LM intuition
Partial equilibrium analysis
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- Term premium might be partly a “wedge”
- Term premium might be related to potential output rather than output gap
### Structural vs. Reduced-Form Analysis

**Structural Analysis**
- Completely answers question of interest, in principle
- But number of practical limitations draw some general insights

**Macro-Finance Analysis**
- Less structural, more tractable
- More successful empirically
- But does not address question of interest

**Reduced-Form Analysis**
- Literature using yield curve spread to forecast GDP
- Compare popular term premium measures
- Study importance of term premium for forecasting GDP
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Structural Analysis

2

- Review Asset Pricing
- Define Benchmark New Keynesian Model
- Graph Impulse Responses
- Discuss Limitations of the Structural Framework
Asset Pricing

Asset pricing:

\[ p_t = E_t \left[ m_{t+1} p_{t+1} \right] \]

Zero-coupon bond pricing:

\[ p(n)_t = E_t \left[ m_{t+n-1} p_{t+n-1} \right] \]

\[ i_t = -\frac{1}{n} \log p(n)_t \]

Notation: let \( i_t \equiv i(1)_t \)
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Notation: let \( i_t \equiv i_t^{(1)} \)
Benchmark New Keynesian Model

Representative household with preferences:

\[ \text{max}_{t \to \infty} \sum_{t=0}^{\infty} \beta^t \left( (c_t - bC_{t-1})^{1-\gamma} - \gamma P_t P_{t+1} \right) \]

Stochastic discount factor:

\[ m_{t+1} = \beta \left( C_t + 1 - bC_t \right) - \gamma \left( C_t - bC_{t-1} \right) - \gamma P_t P_{t+1} \]

Parameters:

\[ \beta = 0.99, \quad b = 0.66, \quad \gamma = 2, \quad \chi = 1.5 \]
Benchmark New Keynesian Model

Representative household with preferences:

\[
\max E_t \sum_{t=0}^{\infty} \beta^t \left( \frac{(c_t - bC_{t-1})^{1-\gamma}}{1 - \gamma} - \chi_0 \frac{l_t^{1+\chi}}{1 + \chi} \right)
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Stochastic discount factor:

$$m_{t+1} = \frac{\beta(C_{t+1} - bC_t)^{-\gamma}}{(C_t - bC_{t-1})^{-\gamma}} \frac{P_t}{P_{t+1}}$$
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Continuum of differentiated firms:
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Continuum of differentiated firms:

- face Dixit-Stiglitz demand with elasticity $\frac{1+\theta}{\theta}$, markup $\theta$
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Parameters $\theta = .2, \rho_A = .9, \sigma_A^2 = .01^2$
Benchmark New Keynesian Model

Government:

\[ G_t = \rho G_{t-1} + \varepsilon_t \]

Parameters:
\[ \rho = 0.9, \sigma^2 = 0.004 \]

Monetary Authority:
\[ i_t = \rho i_{t-1} + \left(1 - \rho\right) \left[i^* + g_y (y_t - y_{t-1}) + g_\pi \pi_t\right] + \varepsilon_{i_t} \]

Parameters:
\[ \rho = 0.7, g_y = 0.5, g_\pi = 2, \sigma^2 = 0.004 \]
Government:
- imposes lump-sum taxes $G_t$ on households
Benchmark New Keynesian Model

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- $G_t = \rho_G G_{t-1} + \varepsilon_t^G$

Parameters
$\rho_G = 0.9$, $\sigma^2_{G} = 0.004^2$
$\rho_i = 0.7$, $g_y = 0$, $g_\pi = 2$, $\sigma^2_{i} = 0.004^2$
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The Term Premium in the Benchmark Model

In DSGE framework, convenient to work with a default-free consol, a perpetuity that pays $1 (nominal) every period.

Price of the consol:

\[ p(\infty)_t = 1 + E_t m_t + 1 \]

Risk-neutral consol price:

\[ p(\infty)_t^{rn} = 1 + e^{-i t} E_t p(\infty)_t^{rn} + 1 \]

Term premium:

\[ \log \left( \frac{p(\infty)_t}{p(\infty)_t^{rn}} \right) - \log \left( \frac{p(\infty)_t^{rn}}{p(\infty)_t^{rn} - 1} \right) \]
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$$\log \left( \frac{p_t^{(\infty)}}{p_t^{(\infty)} - 1} \right) - \log \left( \frac{p_t^{(\infty)rn}}{p_t^{(\infty)rn} - 1} \right)$$
Solving the Model

The benchmark model above has a relatively large number of state variables:
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The benchmark model above has a relatively large number of state variables: $C_{t-1}, A_{t-1}, G_{t-1}, i_{t-1}, \Delta_{t-1}$
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Value function iteration strategies are intractable

We solve the model by approximation around the non-stochastic steady state (perturbation methods). In a first-order approximation, the term premium is zero. In a second-order approximation, the term premium is a constant (sum of variances). So we compute a third-order approximation of the solution around the non-stochastic steady state perturbation. The AIM algorithm in Swanson, Anderson, Levin (2006) quickly computes the $n$th order approximations.
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Figure 1
Impulse Responses to One Percentage Point Federal Funds Rate Shock

Basis points

Term Premium

Output

Basis points

Quarters

Percent

Output

Quarters
Impulse Responses

**Figure 2**

Impulse Responses to One Percent Technology Shock

- **Term Premium**
  - Basis points:
    - 0.00
    - -0.05
    - -0.10
    - -0.15
    - -0.20
    - -0.25
    - -0.30
    - -0.35
  - Quarters:
    - 0
    - 2
    - 4
    - 6
    - 8
    - 10
    - 12
    - 14
    - 16
    - 18
    - 20

- **Output**
  - Percent:
    - 0.00
    - 0.05
    - 0.10
    - 0.15
    - 0.20
  - Quarters:
    - 0
    - 2
    - 4
    - 6
    - 8
    - 10
    - 12
    - 14
    - 16
    - 18
    - 20
Figure 3
Impulse Responses to One Percent Government Purchases Shock

- **Term Premium**
  - Basis points: 0.25
  - Quarters: 0 to 20

- **Output**
  - Percent: 0.7
  - Quarters: 0 to 20
Limitations of the Structural Approach

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- Term premia in benchmark New Keynesian model were very small, very stable
- Representative household assumption may work poorly for asset pricing
Limitations of the Structural Approach

Theoretical Limitations:

- No consensus on how to model equity premium, risk premia in general
- Term premia in benchmark New Keynesian model were very small, very stable
- Representative household assumption may work poorly for asset pricing
- Stochastic pricing kernel may not match standard utility functions used in macroeconomic models
Limitations of the Structural Approach

Computational Limitations:

- Closed-form solutions exist only for simplest possible models.
- Linearization or second-order approximation around nonstochastic steady state is not an option.
- Value function iteration is tractable only for very small models.
- Medium-size New Keynesian models are required to match impulse responses of macroeconomic variables (CEE, ACEL).
- Large-scale models (GEM, SIGMA) becoming standard for macroeconomic policy analysis.
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Macro-Finance Analysis

- VAR-based Macro-Finance Models
- New Keynesian Macro-Finance Models
VAR-based Macro-Finance Models

Literature follows Ang and Piazzesi (2003)
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State variables $X_t$ follow a VAR:

$$X_t = \mu + \Phi X_{t-1} + \Sigma \epsilon_t$$
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Ad hoc stochastic pricing kernel:

$$m_{t+1} = \exp \left( -i_t - \frac{1}{2} \lambda_t' \lambda_t - \lambda_t' \varepsilon_{t+1} \right)$$

with

$$\lambda_t = \lambda_0 + \lambda_1 X_t$$

and $\varepsilon_{t+1}$ conditionally log-normal
VAR-based Macro-Finance Models

Appealing framework that allows changes in macroeconomic variables to affect term premium
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- In Ang-Piazzesi-Wei (2006), term premium assumed to have same effect on economy as changes in risk-neutral rate
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- Linearized IS curve allows no role for term premium.
- Rudebusch-Wu (2004) allow for latent factors to affect economy, but in effect assume that effect of term premium and risk-neutral rate are the same.
Reduced-Form Analysis

- The Yield Curve Slope and Forecasting GDP
- Five Measures of the Term Premium
- Importance of Term Premium for Forecasting GDP
The Yield Curve Slope and Forecasting GDP

A large literature uses slope of yield curve to forecast GDP:

\[(y_{t+4} - y_t) = \beta_0 + \beta_1(y_t - y_{t-4}) + \beta_2(i_t^{(n)} - i_t) + \epsilon_t\]
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Estimates in literature consistently find \( \beta_2 > 0 \), highly significant
The Term Premium and Forecasting GDP

If $i_t^{(n)}$ proxies for $i^*$, then:
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Separate yield curve slope $i_t^{(n)} - i_t$ into:

$$
\left( \frac{1}{n} \sum_{j=0}^{n-1} E_t i_{t+j} - i_t \right) + \left( i_t^{(n)} - \frac{1}{n} \sum_{j=0}^{n-1} E_t i_{t+j} \right)
$$

- expectations component
- term premium
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\begin{align*}
\text{exsp}_t &= \left( \frac{1}{n} \sum_{j=0}^{n-1} E_t i_{t+j} - i_t \right) \\
\text{tp}_t &= \left( i_t^{(n)} - \frac{1}{n} \sum_{j=0}^{n-1} E_t i_{t+j} \right)
\end{align*}
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Generalize basic GDP forecasting equation to:

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- $\beta_2 > \beta_3$ (can reject $\beta_2 = \beta_3$)
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Five Measures of the Term Premium

To conduct empirical analysis, we need a term premium measure:
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   - use VAR to construct risk-neutral 10-year yield
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5. **Cochrane-Piazzesi (2005)**
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Figure 4
Five Measures of the 10-Year Term Premium

- Bernanke-Reinhart-Sack
- Cochrane-Piazzesi
- Kim-Wright
- Rudebusch-Wu
- VAR
Figure 5
Kim-Wright Decomposition of the 10-Year Zero-Coupon Yield

10-year zero-coupon yield
Risk-neutral 10-year zero-coupon yield
10-year term premium
### Table 2
Prediction Equations for GDP Growth

<table>
<thead>
<tr>
<th>Dependent Variable: $y_{t+4} - y_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1962–2005 Sample</td>
</tr>
<tr>
<td>$y_t - y_{t-4}$</td>
</tr>
<tr>
<td>$i_t(n) - i_t$</td>
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Note: we cannot reject hypothesis that coefficients on exsp$_t$, tp$_t$ are equal.
GDP Forecasting Results

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Prediction Equations for GDP Growth dependent variable: $y_{t+4} - y_t$

<table>
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<th>1962–2005 Sample (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_t - y_{t-4}$</td>
<td>0.15 (1.57)</td>
<td>0.12 (1.18)</td>
</tr>
<tr>
<td>$i_t^{(n)} - i_t$</td>
<td>0.64 (3.64)</td>
<td></td>
</tr>
<tr>
<td>$exsp_t$</td>
<td></td>
<td>0.68 (4.03)</td>
</tr>
<tr>
<td>$tp_t$</td>
<td></td>
<td>0.30 (0.92)</td>
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</table>

Note: we cannot reject hypothesis that coefficients on $exsp_t$, $tp_t$ are equal
Recall new Keynesian IS curve:

\[ y_t = -\frac{1}{\gamma} E_t \sum_{j=0}^{\infty} \beta^j (i_{t+j} - \pi_{t+1+j}) + \varepsilon_t \]
Regression Specification

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Suggests that yield spread should be related to level of GDP, rather than growth rate.

To account for nonstationarity, forecasting regression specification should then be:

\[ (y_{t+4} - y_t) = \beta_0 + \beta_1 (y_t - y_{t-4}) + \beta_2 (\text{exsp}_t - \text{exsp}_{t-4}) \]
\[ + \beta_3 (tp_t - tp_{t-4}) + \epsilon_t \]
### GDP Forecasting Results

#### Table 2 (cont.)
Prediction Equations for GDP Growth

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<td>$y_t - y_{t-4}$</td>
<td>0.32 (3.04)</td>
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<tr>
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<td>1.03 (5.64)</td>
</tr>
<tr>
<td>$exsp_{t-4}$</td>
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<tr>
<td>$tp_t$</td>
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Note: we strongly reject hypothesis that coefficients on $exsp_t$, $tp_t$ are equal.
GDP Forecasting Results

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<tr>
<td>$\text{exsp}<em>t - \text{exsp}</em>{t-4}$</td>
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Note: we strongly reject hypothesis that coefficients on $\text{exsp}_t$, $t_p$ are equal
Conclusions

There is no structural, causal relationship running from the term premium to the economy. The correlation is different for different structural shocks.

Reduced-form evidence strongly suggests that policymakers should take term premium into account when forecasting. The hypothesis that $\beta_1 = \beta_2$ in forecasting regression is strongly rejected.

Declines in the term premium have typically been followed by economic expansion, which is true in both the post-1960 and post-1985 periods.
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1. There is no structural, causal relationship running from the term premium to the economy
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Policymakers were right to closely watch declining term premium in 2004-5
Conclusions

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5. Some reduced-form evidence that the Practitioner/Chairman View of macroeconomic implications of declining term premium was correct
Figure 6
Kim-Wright Term Premium and the CBO Output Gap

- 10-year term premium
- Output gap

Percent

Year
Figure 1

Term Premium for Ten-Year Treasury Security
Implied by Cochrane-Piazzesi Results

Basis Points


-300 -200 -100 0 100 200 300 400
Figure 1
Term Premium for Ten-Year Treasury Security
Implied by Cochrane-Piazzesi Results

Figure 2
Comparison of Term Premium and One-Year Expected Excess Returns
for Ten-Year Treasury Security
Table 1
Correlations between Five Measures of the Term Premium

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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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</tr>
<tr>
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<td>1.00</td>
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