Risk and Return in Stocks and Bonds

Princeton Finance Lectures
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Stocks, Bonds, and the Flight to Quality

Princeton Finance Lecture 3
November 5, 2008
John Y. Campbell
The Panic of 2008

• What assets have held their value best?
  – US Treasury bills (stable value)
  – Nominal US Treasury bonds (increasing value)

• Why have nominal Treasuries been such good hedges?
  – “Flight to quality” helps safe assets, but why are nominal Treasuries regarded as safe?
  – They have no credit risk, but they do have inflation risk

• Have nominal Treasuries always hedged investors against other risks?
Understanding Bond Risks

• This lecture explores time-variation in inflation risk and its effect on the nominal Treasury yield curve
• The analysis makes some use of TIPS data but TIPS are not the main focus
• At the end, a brief analysis of currencies along the same lines
Understanding Bond Risks

I draw on several recent pieces of research:


• Campbell, Karine Serfaty-de Medeiros, and Viceira, “Global Currency Hedging”, unpublished, 2008

Why Hold Treasuries?

• Speculative motive
  – Higher yields than money market

• Hedging motive
  – They do well when other assets decline

• At different times, conventional wisdom has emphasized one or the other motive
Changing Conventional Wisdom

- Late 1970’s and early 1980’s:
  - Bonds are exposed to the risk of stagflation
  - Avoid them unless the term premium is high

- 2000’s:
  - Bonds are hedges against the risk of deflation
  - “Anchor to windward”
  - Hold them even at a low term premium

- Changing CW reflects changing reality
  - Bonds as hedges in 2007-2008
Figure 1
CAPM beta of bonds
(1962.07-2003.12)

Realized beta of bonds based on 3-months of daily returns on stocks and bonds.

CAPM beta of bonds (2002.06-2008.09)

3-month centered beta, 10-year Treasury on S&P500
Changing Inflation Behavior

• The changes in measured bond risks appear to be related to changing behavior of the Phillips Curve

• When the Phillips Curve is stable (early 1960’s, 2000’s), inflation falls when unemployment rises
  – Then bonds do well in bad times and hedge macroeconomic risk

• When the Phillips Curve is unstable (1970’s and early 1980’s), inflation and unemployment move together (stagflation)
  – Then bonds do badly in bad times and are risky
Stable Phillips Curve

Inflation ($- R_{bond}$) vs. Unemployment ($- Output$)

- Good times
- Bad times
Stable Phillips Curve

- The Phillips Curve is stable when
  - Supply conditions are stable while demand varies
  - The public’s expectations of inflation are stable because the central bank is credible
- Downside risk is weak demand
  - Extreme examples: deflation in the US during the Great Depression, in Japan during the 1990’s
- Bonds hedge investors against deflation risk
- Accordingly, investors are willing to accept low rates of return on bonds
- The yield curve tends to be flat
  - An explanation of the “Greenspan conundrum”
Unstable Phillips Curve

Inflation (- $R_{bond}$)

Unemployment (- Output)

Bad times

Good times
Unstable Phillips Curve

• The Phillips Curve is unstable when
  – Supply shocks hit the economy
  – Public expectations of inflation are unstable because the central bank has lost credibility

• The downside risk is stagflation
  – Examples: worldwide stagflation of the 1970’s and early 1980’s

• Bonds fail to protect investors
  – Henry Kaufman, “Dr. Doom”

• When investors catch on, they demand high rates of return on bonds

• The yield curve tends to be steep
Modelling the Yield Curve

• How well does this story explain the history of Treasury yields?
Figure 3
CAPM beta of bonds and the yield spread
(1962.07-2003.12)

Realized beta of bonds based on 3-months of daily returns on stocks and bonds (right axis), and annualized log yield spread (right axis).

Modelling the Yield Curve

• Changing bond risk does seem to matter over the long run
• In the short run, however, there are other influences on the yield curve
• To capture its movements, we need to consider more traditional factors as well:
  – The real interest rate
  – Investor attitudes towards risk
  – Expected inflation
• Campbell, Sunderam, and Viceira 2008 undertakes this project
A Bond Pricing Model

• We consider five factors that move in different ways:
  – Real interest rate $x_t$ (transient)
  – Risk aversion $z_t$ (persistent)
  – Long-run expected inflation $\lambda_t$ (permanent)
  – Temporary expected inflation $\xi_t$ (transient)
  – Covariance of inflation with recession $\psi_t$ (persistent, can change sign)

• The five factors are not directly observed, so we back out their implied values from data we do observe
  – Nonlinear Kalman filtering
Real Term Structure

• Real stochastic discount factor (SDF):

\[-m_{t+1} = x_t + \frac{\sigma_m^2}{2} z_t^2 + z_t \varepsilon_{m,t+1};\]

• \(x_t\) is real rate:

\[y_{1t} = - E_t [m_{t+1}] - \frac{1}{2} \text{Var}_t (m_{t+1}) = x_t\]

• \(z_t\) drives time-variation in volatility of SDF:

\[\text{Var}_t (m_{t+1}) = z_t^2\]

• \(x_t\) and \(z_t\) follow AR(1) processes:

\[x_{t+1} = \mu_x (1 - \phi_x) + \phi_x x_t + \varepsilon_{x,t+1},\]

\[z_{t+1} = \mu_z (1 - \phi_z) + \phi_z z_t + \varepsilon_{z,t+1},\]
Real Term Structure

- Real (inflation-indexed) term structure is affine in the short-term real interest rate and aggregate risk aversion:

\[ P_{n,t} = \exp \{ A_n + B_{x,n} x_t + B_{z,n} z_t \} \]

- Simple pricing structure, yet risk premium on real bonds varies over time.
Risk Premia on Real Assets

• $z_t$ drives exogenous time-variation in real risk premia.

• Real bonds:

$$E_t [r_{n,t+1} - r_{1,t+1}] + \frac{1}{2} Var_t (r_{n,t+1} - r_{1,t+1}) = (B_{x,n-1} \sigma_{mx} + B_{z,n-1} \sigma_{mz}) \sim_t$$

• Equities:

$$E_t [r_{e,t+1} - r_{1,t+1}] + \frac{1}{2} Var_t (r_{e,t+1} - r_{1,t+1}) = (\beta_{ex} \sigma_{xm} + \beta_{em} \sigma_m^2) \sim_t.$$
Nominal Term Structure

- Log inflation (reciprocal of real cash flow on 1-period bonds):

\[
\pi_{t+1} = \lambda_t + \xi_t + \frac{\sigma^2}{2} \psi_t^2 + \psi_t \varepsilon_{\pi,t+1},
\]

- Expected inflation is time-varying, with two components:

  - Permanent component:

    \[
    \lambda_{t+1} = \lambda_t + \varepsilon_{\Lambda,t+1} + \psi_t \varepsilon_{\lambda,t+1}
    \]

  - Transitory component:

    \[
    \xi_{t+1} = \phi \xi \xi_t + \psi_t \varepsilon_{\xi,t+1}.
    \]
Nominal Term Structure

• State variable $\psi_t$ follows AR(1) process:

$$\psi_{t+1} = \mu_\psi (1 - \phi_\psi) + \phi_\psi \psi_t + \varepsilon_{\psi,t+1}.$$  

This variable is the main innovation of our model, and plays important role:

• $(\psi_t)^2$ drives time variation in the conditional volatility of both realized inflation and expected inflation.

• $z_t \psi_t$ drives time variation in the covariance of the real economy with inflation, and thus determines nominal bond risk premia.

• This covariance (and thus bond risk premia) can switch sign as $\psi_t$ takes positive or negative values ($z_t$ is always positive in the data)
Nominal Term Structure

• Log nominal SDF:

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

• Log nominal short rate:

\[ y_{1,t+1}^S = x_t + \lambda_t + \xi_t + \text{Cov}_t (m_{t+1}, \pi_{t+1}) \]

- Fisher equation
- Inflation risk premium

• The conditional covariance between the real economy (log real SDF) and log inflation determines risk premium on short-term nominal bonds:

\[ \text{Cov}_t (m_{t+1}, \pi_{t+1}) = -\sigma m\pi z_t \psi_t. \]
Nominal Term Structure

• Nominal term structure is linear-quadratic:

\[
P_{n,t}^s = \exp \left\{ A_n^s + B_{x,n}^s x_t + B_{z,n}^s z_t + B_{n}^s \lambda_t + B_{\xi,n}^s \xi_t + B_{\psi,n}^s \psi_t + C_{z,n}^s z_t^2 + C_{\psi,n}^s \psi_t^2 + C_{z\psi,n}^s z_t \psi_t \right\}
\]

• The risk premium on nominal bonds is the real-bond risk premium plus a term in the cross-product \( Z_t \psi_t \).
Nested Models

• Both $z_t$ and $\psi_t$ constant
  – Both real bond risk premia and nominal risk premia are constant.

• $z_t$ varying and $\psi_t$ constant
  – Both real bond risk premia and nominal bond risk premia vary with aggregate risk aversion

• $z_t$ constant and $\psi_t$ varying
  – Single-factor affine yield model for the real term structure, and a linear-quadratic model for the term structure for nominal interest rates.
  – Constant real bond risk premia, time-varying nominal bond risk premia.
Estimation

• Maximum likelihood via nonlinear Kalman filter because state variables are unobserved.
• Unscented Kalman filter (Julier and Uhlmann 1997, Wan and van der Merwe 2000, Kojien and Binsbergen 2008)
Observed Variables

- Nominal yield curve at maturities 3 months, 1 year, 3 years, 10 years
- TIPS yield
- Realized inflation
- Equity returns and dividend yield (proxy for risk aversion)
- Realized bond variance and bond-equity covariance in daily data
Nominal Yields
Real Yields
Equity Dividend Yield
Bond Second Moments

**Bond-Equity Covariance**

**Bond Variance**
Real State Variables

Real Interest Rate

Risk Aversion
Inflation Components

Permanent Expected Inflation

Temporary Expected Inflation
Inflation-Recession Covariance

Time Series of $\psi_t$

Stagflation risk

Deflation risk

Year

Implications for the Yield Curve

- We plot the yield curve at the sample mean of all the state variables.
- Then we vary each state variable to its sample minimum and maximum, while holding the other state variables at their sample mean.
Real Interest Rate

Real Yield Curve

Nominal Yield Curve
Risk Aversion

Real Yield Curve

Nominal Yield Curve
Inflation

Permanent Expected Inflation

Temporary Expected Inflation
Inflation-Recession Covariance

![Graph showing yield (annualized %) vs. maturity (quarters). The graph includes three lines: blue for mean, green dotted for max \( \psi \), and red dashed for min \( \psi \).]
Implications for the Yield Curve

• Real interest rate and temporary expected inflation move the short end
• Risk aversion moves the long end
• Permanent expected inflation moves the yield curve up and down in parallel
• Inflation-recession covariance drives the curvature of the yield curve
Implications for the Yield Curve

- Fixed-income practitioners analyze the yield curve using level, slope, and curvature factors.
- They do not relate these factors to external market conditions.
- Our model does:
  - Real interest rate and permanent expected inflation drive the level factor.
  - Real interest rate, risk aversion, and temporary expected inflation drive the slope factor.
  - Inflation-recession covariance drives the curvature factor.
Implications for Bond Returns

• What happens when investors become more risk averse?
• If bonds are risky, then investors sell both stocks and bonds
• If bonds are hedges, then investors sell stocks and buy bonds (flight to quality)
• Thus movements in risk aversion amplify the covariance of bonds and stocks
  – If the covariance is positive, it becomes more positive
  – If the covariance is negative, it becomes more negative
Implications for Term Premia

• Expected excess bond returns (term premia) are determined by
  – Price of risk × quantity of risk
  – Risk aversion × inflation-recession covariance
  – $z \times \psi$

• Both matter, but the inflation-recession covariance $\psi$ is more important
Implications for Term Premia
Implications for Term Premia

Time Series of 10yr Nominal EXR

Annualized %

Year


Expected Excess Returns
Forecasting Bond Returns

• Both academics and investors are interested in forecasting excess bond returns over bills

• Traditional approach, e.g. Campbell and Shiller (1991), is to use the yield spread

• Cochrane and Piazzesi (2005) find a linear combination of interest rates that predicts excess bond returns even better than the yield spread
  – Their measure is roughly the level of the 3-year forward rate relative to the weighted average of 1-year and 5-year forward rates
  – Thus it captures the curvature of the yield curve
Cochrane-Piazzesi Predictor
Forecasting Bond Returns

• Why does this work?
• Our model’s explanation:
  – Inflation-recession covariance \( \psi \) increases the risk premium, which raises bond yields
  – This effect is particularly powerful at intermediate maturities, because the largest risk premium is on the temporary component of expected inflation
  – But \( \psi \) also increases interest rate volatility, which benefits long bonds because they are “convex” (they benefit more when rates fall than they suffer when rates rise)
  – Investors understand convexity, so volatility lowers the long yield
  – The first effect dominates at 3 year maturity, but less so as maturity increases
The Term Structure Today

• Investors still trust nominal Treasuries as hedges
  – Little curvature in the Treasury yield curve
  – Stable and declining long Treasury yields

• This trust has been well founded recently
  – Treasuries have covaried negatively with stocks over the past year
  – Panic of 2008 makes inflation procyclical (deflation as the bad outcome)

• But what about the future?
  – Energy supply risks remain
  – New risk of destabilized inflation expectations from expensive financial bailouts
What About TIPS?

• Research in progress with Shiller and Viceira looks at daily variances and covariances of inflation-indexed bonds (TIPS) along with nominal Treasuries

• Campbell-Sunderam-Viceira model assumes TIPS-Treasury covariance is time-varying while TIPS-equity covariance is constant

• But for most of this decade, the TIPS-Treasury correlation was around 0.9 while the TIPS-equity correlation moved closely with nominal bond-equity correlation
  – Divergence in September-October 2008
Std. of US breakeven inflation and correlation between daily holding returns real/nominal bonds

- std breakeven inflation 10YR bonds
- std breakeven inflation 20YR bonds

Corr. daily returns 10YR real/nominal bonds
Corr. daily returns 20 YR real/nominal bonds
Corr. daily return US real bonds, nominal bonds and breakeven inflation with US stock
Currency Risks

- Campbell, Serfaty-de Medeiros, and Viceira, 2008, show that the US dollar, the euro, and the Swiss franc tended to move against the stock market in the period 1975-2005
- The bilateral US-Canadian rate was a particularly good equity hedge
- The euro became a better hedge in the second half of the period
US Dollar as a Hedge

![Graph showing US Dollar as a Hedge](image-url)
Euro as a Hedge

[Graph showing the performance of the Euro and the world stock market over time.]
Table 4
Optimal currency exposure for an equally-weighted global equity portfolio: multiple-currency case

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Currency</th>
<th>Euroland</th>
<th>Australia</th>
<th>Canada</th>
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<td>-0.17*</td>
<td>0.27*</td>
<td>-0.10</td>
<td>0.40**</td>
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<td>(0.09)</td>
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<td>(0.11)</td>
<td>(0.18)</td>
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<td>-0.63**</td>
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<td><strong>Panel B : 5 country optimization</strong></td>
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<td>Full period</td>
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Dollar falls on doubts for its safe-haven status. By Peter Garnham.

The dollar suffered yesterday as coordinated action from global central banks to ease liquidity tension in the world's money markets dented its newly found status as a safe-haven currency. Analysts said the dollar had previously benefited as worries over the state of the global financial system heightened risk aversion, prompting US investors to repatriate funds that had been invested in global equities, while lower inflation expectations had supported demand for US bonds.

"In a world where cross-border equity investing collapses and bond flows remain stable, there is a net inflow back into the dollar", said Michael Metcalfe of State Street Global Markets.

However, analysts said the decision by global central banks to inject $180bn of emergency dollar liquidity into the market had helped boost risk appetite and damp demand for the dollar.... The dollar's losses were largest against the high-yielding Australian and New Zealand dollars, which had been the worst hit among leading currencies during the recent market turmoil.

Financial Times, September 19, 2008
Currencies in 2008

• Many of these results hold up during the financial crisis
• But the euro has performed worse, and the yen better, than historical patterns predicted
• What is driving these patterns?
  – Currencies that are equity hedges are widely used as reserve currencies
  – They benefit from flight to quality
  – But what are the fundamentals that lead investors to regard them as safe in the first place?
Conclusion

- Asset allocation analysis often assumes stable risks of asset classes
- This is a mistake, just as it is a mistake to assume constant expected returns
Conclusion

• Asset class risks change with the macroeconomic environment

• The risks of nominal bonds depend on whether deflation or stagflation is the greater threat

• Bonds can be used to hedge against deflation, but the hedge fails in stagflation

• What will be the risks in the future?