

Discussion of “Inflation Bets or Deflation Hedges?  
The Changing Risks of Nominal Bonds.”  
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## Motivation

- ▶ Lot of evidence that nominal bond returns are predictable
  - ▶ Returns on long-term bonds are larger when the slope of the yield curve is steep
  - ▶ Average term premia are positive but small.
  - ▶ Term premia are time varying (and even may change sign).
  - ▶ Returns on long-term bonds are *not* related to bond volatility. (Fama and Bliss (1987), Fama-French (1993), Duffee (2002), Dai-Singleton (2002), Cochrane and Piazzesi (2005))
- ▶ This paper investigates what is the source of these risk-premia, and, in particular, whether this is compensation for time-varying inflation risk.
- ▶ Intuition from Phillips curve:
  - ▶ When there is a stable trade-off between inflation and unemployment an increase in inflation is good as it leads to higher aggregate output. However, higher inflation also leads to lower real returns on nominal bonds. Therefore nominal bonds are natural 'deflation' hedges and should have low risk-premia. (pre-70's, now?)
  - ▶ When there is no relation between inflation and output: an increase in inflation is bad as it leads to lower growth. Since higher inflation also leads to lower real returns on nominal bonds, nominal bonds are 'inflation bets' and should have high risk-premia.

## Model

- ▶ Propose a four factor quadratic-affine model of the nominal term structure:
  - ▶ Pricing Kernel  $M(t)$  has dynamics:

$$\frac{dM(t)}{M(t)} = -R(t)dt - Z(t)d\epsilon_M(t)$$

- ▶ Historical dynamics of real rate ( $R(t)$ ) is Gaussian AR1.
- ▶ 'Risk-aversion' ( $Z(t)$ ) follows Gaussian AR1 process (with correlated innovations).
- ▶ Price of a zero-coupon Real bond is  $P(T) = E[M(T) 1]$
- ⇒ Resulting Real term structure is special case of two-factor Vasicek with essentially affine risk-premia (Duffee (2002)).

- ▶ Nominal price process  $\Pi(t)$  has following dynamics:

$$\frac{d\Pi(t)}{\Pi(t)} = \xi(t)dt + \psi(t)d\epsilon_\Pi(t)$$

- ▶ Expected inflation  $\xi(t)$  follows AR1 with conditional volatility  $\psi(t)$ .
- ▶ Conditional volatility (of both expected and realized inflation)  $\psi(t)$  follows Gaussian AR1 process.
- ▶ The price of a nominal Bond is:  $P^{\$}(T) = E[M(T) \frac{1}{\Pi(T)}]$
- ⇒ The resulting nominal term structure is a quadratic-affine model (Ahn et al.) with nominal short rate given by:  $R^{\$(t)} = R(t) + \xi(t) - \sigma_{M\Pi} Z(t)\psi(t)$

## Empirical Estimation

- ▶ Define set of measurement equations:
  - ▶ Monthly observations of 3 month, 1, 3, 10 year nominal bond yields:  $P^{\$}(R, \xi, Z, \psi)$ .
  - ▶ Realized inflation equal to expected inflation ( $\xi$ ) and inflation volatility ( $\psi$ ).
  - ▶ Realized log equity returns equal real rate ( $R$ ) plus risk-premium ( $Z$ ) plus noise.
  - ▶ Assume dividend/price ratio on equities is linear in risk-aversion:  $\frac{D}{P} = \alpha + \beta Z + \epsilon$ .
  - ▶ Uses the fact that conditional covariance of equity and nominal bond returns is linear in inflation volatility to identify  $\psi$  from rolling 1-year window covariances between daily stock and bond returns.
  
- ▶ Uses the Kalman filter to estimate latent state variables and parameter values.

## Results

- ▶ Model predicts time variation in risk-premia on both real and nominal bond returns
    - ▶ Real bond risk premia driven by risk-aversion  $Z$ .
    - ▶ Nominal bond risk premia driven by both risk-aversion ( $Z$ ) and inflation volatility ( $\psi$ ).
  - ▶ Changes in  $Z$  affect mostly the slope of the yield curve (both real and nominal).
  - ▶ Changes in  $\psi$  affect both slope and curvature of the nominal yield curve.
- ⇒ Gives interpretation in terms of
- ▶ level factors (expected inflation  $\xi$ ).
  - ▶ slope factors (real rate  $R$  and risk aversion  $Z$ ).
  - ▶ curvature factors (inflation volatility  $\psi$ ).
- ⇒ Since  $Z$  is always positive it is  $\psi$  which drives the time-variation in the sign of nominal bond risk-premia
- ⇒ Together gives justification for Cochrane Piazzesi's result that a tent-shaped ( $\sim$  curvature) combination of non-overlapping forward rates gives best forecast of bond risk-premia.

## Questions/Comments

- ▶ Why impose risk-aversion to be linear in dividend price ratio?
  - ▶ Are Price/Dividend and real term structure slope highly correlated?
  - ▶ Does it affect relative importance of  $\psi$  and  $Z$  for nominal bond risk-premia?
  - ▶ If used Credit spreads as a measure of risk-aversion would get different results. (Price/dividend affected by payout policy decisions etc...).
  - ▶ Wouldn't a solution of the model deliver  $\log(P/D)$  approx. linear in all state variables?
  
- ▶ Why assume that realized inflation and expected inflation have the same conditional volatility ( $\psi$ )?
  - ▶ Model implies that  $\psi$  also drives the covariance of equity and bond returns.
  - ⇒ Some evidence (Li 2002) that volatility of expected inflation is more relevant for explaining the correlation of stock and bond returns than that of unexpected realized inflation.
  
- ▶ Why assume that stock returns are homoscedastic?
  - ▶ Implies that risk-premia on stocks are perfectly correlated with risk-premia on real-bonds.
  - ⇒ Some evidence (Mamaysky 2001, Li 2002) that there are stock-market specific priced shocks and, likely, associated time-varying risk-premia not perfectly correlated with bond risk-premia.

## Comments

- ▶ Does the model Explain the tent-shaped factor of Cochrane and Piazzesi?
  - ▶ CP find that one can increase predictability by adding *all* non-overlapping forward rates to the right-hand side of the regression.
  - ▶ The present model is a four-factor quadratic model so *any* four yields should do *equally* well as predictors. (Of course, need appropriate combination of the yields to best approximate  $Z, \psi$ ).
- ▶ Quadratic versus Affine models?
  - ▶ Quadratic models of the type investigated in this paper are constrained versions of affine models (Duffie Kan (1996)).
  - ▶ Advantage: the unconstrained affine models would have  $\sim 14$  state variables.
  - ▶ Disadvantage: how restrictive are restrictions?



## Conclusion

- ▶ Are bond-risk premia compensation for inflation risk?
  - ⇒ Evidence seems convincing, however would like to see estimation that does not impose the relation between  $Z$  and  $P/D$ , and between  $\psi$  and stock-bond return correlation.
- ▶ Since propose a latent state variables bond pricing model, would seem natural to estimate these variables solely from bond prices (and inflation data) and see how they relate to equity returns and bond/stock covariances. Could use 'measurement' equations as out of sample tests:
  - ▶ Is the latent bond-market risk-aversion state variable really related to the price-dividend ratio?
  - ▶ Is the latent bond curvature factor related to the nominal bond return beta?
  - ▶ Do the restrictions help with out-of-sample forecasting of bond returns?
- ▶ Are the model and the results consistent with the original Phillips curve intuition?
  - ⇒ Both model and Phillips curve intuition are based on consumption CAPM. We should expect covariance of Nominal bond returns with aggregate consumption to 'explain' risk-premia on nominal bonds. Does it?
- ▶ Interesting paper with potential important implications for stock-bond asset allocation!