Dividend Habitats

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Preliminary!

Motivation

Broad Empirical Facts

- Strong patterns in stock returns: equity premium puzzle, excess volatility (Mehra & Prescott 1985, Shiller 1981...)
- Strong patterns in the term structure of bond returns: deviations from the Expectation Hypothesis (EH) (Fama & Bliss 1987, Campbell & Shiller 1991...)
- Strong patterns in the term structure of equity returns (van Binsbergen et. al. 2012, Gormsen 2020, Giglio et. al. 2021...)
- QE (which affects term premia) seems to have strong effects on equities even with policy rates unchanged at the ZLB...

Bond and Equity Response to QE

$\Longrightarrow$ Quantities matter for explaining joint behavior of bond and equity risk premia

Motivation

This is important...

- To understand how conventional monetary policy transmits along the yield curve...
- ...but also transmission to other (risky) asset prices
- To understand the transmission of QE...
  - QE becoming more and more conventional
  - Spillovers of different types of QE (Treasuries vs. corporate bonds vs. ...)

What We (Want to...) Do

What We Do:

- Develop a model of risk-averse arbitrageurs who absorb supply/demand shocks in fixed-income and equity markets
  - Arbitrageurs: hedge funds, prop trading desk of investment banks, ...
  - Supply/demand shocks: QE, pension funds, mutual funds, ...
- Formally: extend the Vayanos & Vila (2021) preferred-habitat (PH) model of bond markets to risky assets
  - Introduce a term structure of dividend strips

Why:

- Natural and successful modelling approach to make sense of the role of quantities (bond markets, FX markets, ...)

What We Want to Do:

- Test and/or discipline the model with mutual fund holdings data

Preview of Results

- Relatively tractable extension of the PH framework
- When markets are not perfectly integrated, rich transmission of monetary policy shocks via bond and equity term premia
- Particularly true for unconventional policies like QE

Speculative...

- The model is able to generate interesting time-variation in the term structure of bond and equity premia
- However, remains to be seen if the model is quantitatively successful

Model

Model Setup: Assets

- Continuous time $t \in (0, \infty)$. Sets of assets: zero-coupon bonds and dividend strips
- Bonds:
  - Price $P_t^{(\tau)}$ with payoff \$1 at maturity in period $t + \tau$
  - Yield to maturity $y_t^{(\tau)} = -\frac{1}{\tau} \log P_t^{(\tau)}$
- Dividend strips/risky assets:
  - Price $\tilde{P}_t^{(\tau)}$ with payoff $D_{t+\tau} \equiv e^{d_{t+\tau}}$ at maturity in period $t + \tau$
  - D_t is the (stochastic) dividend process: risky asset with uncertain payoff
  - Equity yield $\tilde{y}_t^{(\tau)} = -\frac{1}{\tau} \log \tilde{P}_t^{(\tau)} / D_t$
- The instantaneous risk-free bond $\tau \to 0$ has risk-free rate $y_t^{(\tau)} \to i_t$
- Partial equilibrium: the risk-free rate i_t and dividend process d_t follow exogenous stochastic processes

$$\mathrm{d}i_t = -\kappa_i(i_t - \bar{i})\,\mathrm{d}t + \sigma_i \mathrm{d}B_{it}, \quad \mathrm{d}d_t = -\kappa_d(i_t - \bar{d})\,\mathrm{d}t + \sigma_d \mathrm{d}B_{dt}$$

Model Setup: Investors

Three types of investors:

- Preferred-habitat bond investors
  [hold bonds of a specific maturity]
- Preferred-habitat dividend investors
  [hold risky assets of a specific maturity]
- Arbitrageurs
  [can trade in both markets, across all maturities]

Arbitrageurs' Allocation Problem

- Wealth W_t:
  - $X_t^{(\tau)}$ invested in τ bonds
  - $\tilde{X}_t^{(\tau)}$ invested in τ dividend strips
  - Remainder in instantaneous short rate i_t
- Instantaneous mean-variance optimization:

$$\max \mathsf{E}_t[\mathrm{d}W_t] - \frac{a}{2}\mathsf{Var}_t[\mathrm{d}W_t]$$

$$\text{s.t.}\;\; \mathrm{d}W_t = \left(W_t - \int_0^T X_t^{(\tau)}\,\mathrm{d}\tau - \int_0^T \tilde{X}_t^{(\tau)}\,\mathrm{d}\tau\right) i_t\,\mathrm{d}t + \int_0^T X_t^{(\tau)}\frac{\mathrm{d}P_t^{(\tau)}}{P_t^{(\tau)}}\,\mathrm{d}\tau + \int_0^T \tilde{X}_t^{(\tau)}\frac{\mathrm{d}\tilde{P}_t^{(\tau)}}{\tilde{P}_t^{(\tau)}}\,\mathrm{d}\tau$$

Key insight: Arbitrageurs require compensation for increasing holdings

Preferred-Habitat Investors

- Demand for bonds of maturity τ:

$$Z_t^{(\tau)} = -\alpha(\tau) \log P_t^{(\tau)} - \theta(\tau)\beta_t$$

- Demand for dividend strips of maturity τ:

$$\tilde{Z}_t^{(\tau)} = -\tilde{\alpha}(\tau) \log \tilde{P}_t^{(\tau)} - \tilde{\theta}(\tau)\tilde{\beta}_t$$

- Exogenous bond and risky demand factors:

$$\mathrm{d}\beta_t = -\kappa_\beta \beta_t \, \mathrm{d}t + \sigma_\beta \mathrm{d}B_{\beta t}, \quad \mathrm{d}\tilde{\beta}_t = -\kappa_{\tilde{\beta}} \tilde{\beta}_t \, \mathrm{d}t + \sigma_{\tilde{\beta}} \mathrm{d}B_{\tilde{\beta} t}$$

Key Insight: Price elastic habitat traders. Price movements require portfolio rebalancing

Market Clearing

- Bonds and risky assets:

$$X_t^{(\tau)} + Z_t^{(\tau)} = 0, \quad \tilde{X}_t^{(\tau)} + \tilde{Z}_t^{(\tau)} = 0$$

- 4 risk factors: short rate ($\mathrm{d}B_{it}$), dividends ($\mathrm{d}B_{dt}$), bond demand ($\mathrm{d}B_{\beta t}$), risky asset demand ($\mathrm{d}B_{\tilde{\beta} t}$)

- Equilibrium: affine term structure model

$$-\log P_t^{(\tau)} = \mathbf{A}(\tau)^\top \mathbf{q}_t + C(\tau), \quad -\log \tilde{P}_t^{(\tau)} = \tilde{\mathbf{A}}(\tau)^\top \mathbf{q}_t + \tilde{C}(\tau)$$

where $\mathbf{q}_t = \begin{bmatrix} i_t & d_t & \beta_t & \tilde{\beta}_t \end{bmatrix}^\top$

Risk Neutral Arbitrageur (aka Standard Model)

0. Benchmark: Risk Neutral Arbitrageur

Consider the benchmark case of a risk neutral arbitrageur: $a = 0$

- Expected returns equalized:

$$\mathrm{E}_t \left[\mathrm{d}P_t^{(\tau)} / P_t^{(\tau)} \right] = \mathrm{E}_t \left[\mathrm{d}\tilde{P}_t^{(\tau)} / \tilde{P}_t^{(\tau)} \right] = i_t$$

- No effect of QE on bond yields or equity yields
- Bond yield curve independent of dividend shocks

"Woodford-ian" result:

- Monetary policy "stance" can be fully characterized by the short rate i_t
- Yield curve insulated from all other shocks

Isolated Short Rate/Dividend Risk

1. Isolating the Sources of Risk: i_t

Consider the case of only short rate risk: $\sigma_i > 0$ and $d_t = \bar{d}, \beta_t = \tilde{\beta}_t = 0$

Proposition (Short Rate Risk Only)

When i_t is the only risk factor: bonds and risky assets fall one-for-one in response to changes in i_t: $A_i(\tau) = \tilde{A}_i(\tau) > 0$

If risk aversion $a > 0$, and elasticities $\alpha(\tau) > 0$ or $\tilde{\alpha}(\tau) > 0$:

- Attenuation: $0 < A_i(\tau) < \frac{1-e^{-\kappa_i}}{\kappa_i}$
- Excess returns: $\frac{\partial}{\partial i_t}\left(\mathrm{E}_t \, \mathrm{d}P_t^{(\tau)} / P_t^{(\tau)} - i_t\right) = \frac{\partial}{\partial i_t}\left(\mathrm{E}_t \, \mathrm{d}\tilde{P}_t^{(\tau)} / \tilde{P}_t^{(\tau)} - i_t\right) < 0$

Intuition:

- When $i_t \downarrow$ arbitrageurs want to invest more in (bond/risky) CT $\implies P_t^{(\tau)}, \tilde{P}_t^{(\tau)} \uparrow$
- As $P_t^{(\tau)}, \tilde{P}_t^{(\tau)} \uparrow$, price-elastic habitat investors ($\alpha(\tau) > 0$ or $\tilde{\alpha}(\tau) > 0$) reduce their holdings $\implies Z_t^{(\tau)}, \tilde{Z}_t^{(\tau)} \downarrow$
- Arbitrageurs increase their holdings, which requires a larger CT return

1. Isolating the Sources of Risk: d_t

Consider the case of only dividend risk: $\sigma_d > 0$ and $i_t = \bar{i}, \beta_t = \tilde{\beta}_t = 0$

Proposition (Dividend Risk Only)

When d_t is the only risk factor: bond prices are fixed: $A_d(\tau) = 0$. Risky asset prices increase in response to changes in d_t: $\tilde{A}_d(\tau) < 0$

If risk aversion $a > 0$, and elasticities $\tilde{\alpha}(\tau) > 0$:

- Attenuation: $-e^{-\kappa_d \tau} < \tilde{A}_d(\tau) < 0$
- Excess returns: $\frac{\partial}{\partial d_t}\left(\mathrm{E}_t \, \mathrm{d}\tilde{P}_t^{(\tau)} / \tilde{P}_t^{(\tau)} - \bar{i}\right) > 0, \to 0$ as $\tau \to \infty$

Intuition:

- When $d_t \uparrow$ arbitrageurs want to invest more in risky CT $\implies \tilde{P}_t^{(\tau)} \uparrow$
- As $\tilde{P}_t^{(\tau)} \uparrow$, price-elastic risky habitat investors ($\tilde{\alpha}(\tau) > 0$) reduce their holdings $\implies \tilde{Z}_t^{(\tau)} \downarrow$
- Arbitrageurs increase their holdings, which requires a larger risky CT return

1. Macro Implications of Isolated Risk Models

Assume that $a > 0$ and $\theta(\tau) > 0, \tilde{\theta}(\tau) > 0$. If d_t is the only risk factor:

- Unexpected increase in bond demand (eg, QE purchase of Treasuries) has no effect on bond yields or risky asset prices
- Unexpected increase in risky asset demand (eg, QE purchase of risky assets) has no effect on bond yields, but reduces equity yields

Stance of Monetary Policy:

- Dividends and demand shocks have no effect on yield curve. Similar to RN benchmark?
- However, this result only follows if we artificially ignore risk sources

Joint Short Rate and Dividend Risk

2. Joint Short Rate and Dividend Risk

Consider the case of short rate and dividend risk: $\sigma_i > 0, \sigma_d > 0$ and $\beta_t = \tilde{\beta}_t = 0$

Proposition (Joint Short Rate and Dividend Risk)

If risk aversion $a > 0$, and elasticities $\alpha(\tau) > 0$ or $\tilde{\alpha}(\tau) > 0$:

- Bond prices fall following an increase in i_t or d_t: $A_i(\tau) > 0, A_d(\tau) > 0$
- Risky asset prices fall following an increase in i_t: $A_i(\tau) > \tilde{A}_i(\tau) > 0$
- Short-term risky asset prices rise in following an increase in d_t, but long-term risky asset prices fall: $\tilde{A}_d(0) < 0, \lim_{\tau\to\infty} \tilde{A}_d(\tau) = \lim_{\tau\to\infty} A_d(\tau) > 0$

Intuition: Bond and equity term premia cross-linkages

- When $d_t \uparrow$, arbitrageurs hold more risky assets, hence are more exposed to risk ($i_t \uparrow$)
- Hedge this by selling assets which lose value when i_t rises (bonds and dividend strips)
- Hence bond prices decline (for all maturities) as do long-term risky asset prices

2. Macro Implications of Joint Risk Model

Assume that $a > 0$ and $\theta(\tau) > 0, \tilde{\theta}(\tau) > 0$.

- Unexpected increase in either bond or risky asset demand reduces both bond yields and equity yields

Stance of Monetary Policy:

- No longer fully summarized by the short rate i_t
- Yield curve responds to changes in dividends as well as demand shocks in bond and equity markets
- Failure of the “Woodford-ian” view of the stance of monetary policy

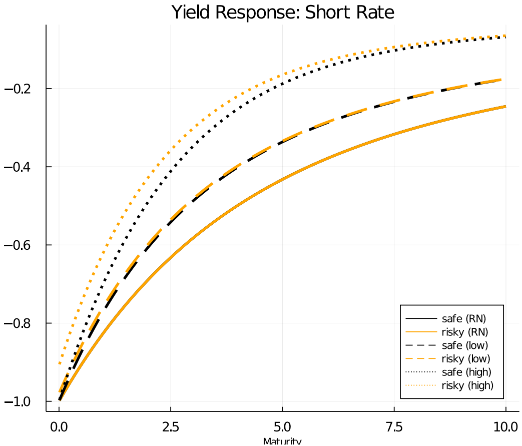
The Full Model

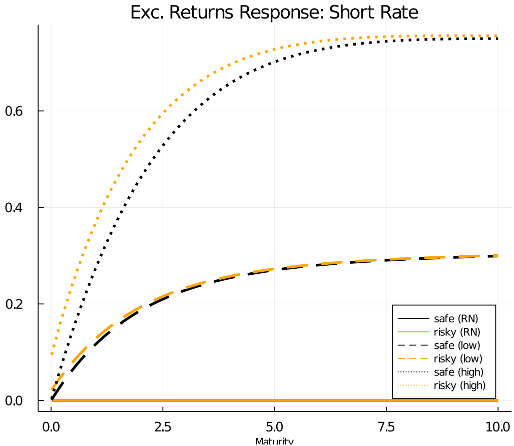
- Collect all of the state variables (instantaneous risk-free rate i_t, dividend process d_t, and demand factors $\beta_t, \tilde{\beta}_t$) in a vector $\mathbf{q}_t = \begin{bmatrix} i_t & d_t & \beta_t & \tilde{\beta}_t \end{bmatrix}^\top$. Assume the following vector OU process:

$$\mathrm{d}\mathbf{q}_t = -\Gamma(\mathbf{y}_t - \bar{\mathbf{y}})\,\mathrm{d}t + \boldsymbol{\sigma}\,\mathrm{d}\mathbf{B}_t$$

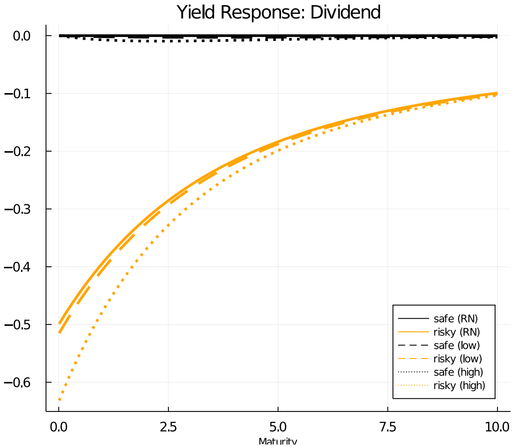
- Examples:
  - Simplest version: all state variables are independent $\implies$ $\Gamma, \boldsymbol{\sigma}$ are diagonal matrices
  - More realistic: dividend process correlated with/responds to movements in short rate (as a proxy for macroeconomic conditions)
- Model must be solved numerically $\implies$ (eventually) estimate the model
- For today, just a few toy calibration exercises

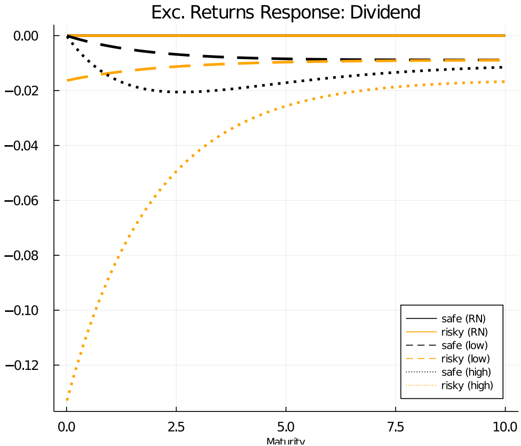
Response to Short Rate Cut



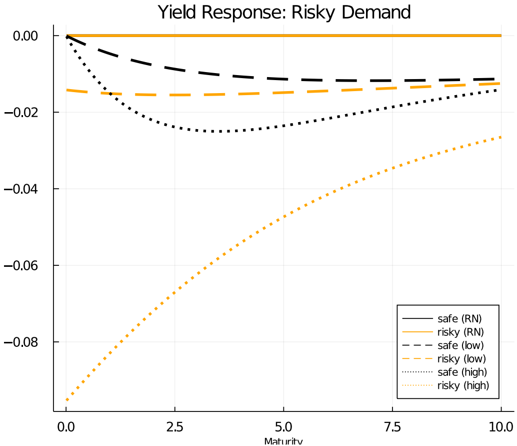


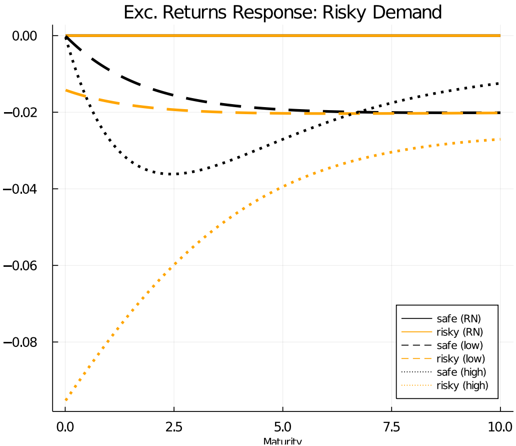
Response to Fall in Dividends



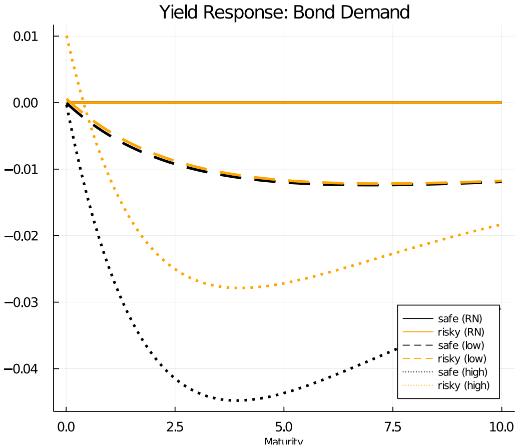


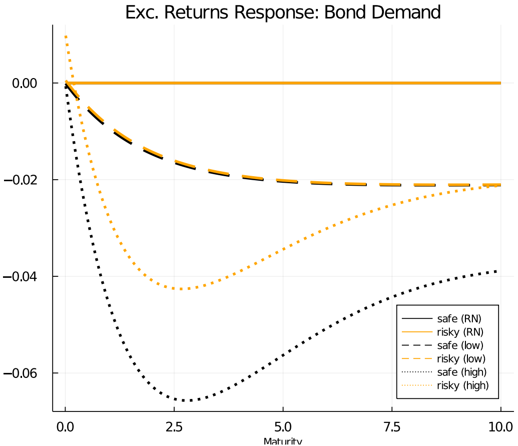
Response to Increase in Risky Demand





Response to Increase in Bond Demand





Next Steps

Next Steps

- Model makes strong predictions about the flow of holdings in response to shocks (either through elasticities $\alpha(\tau), \tilde{\alpha}(\tau)$ or in response to time-varying demand $\beta_t, \tilde{\beta}_t$)
- Can utilize detailed data on mutual fund holdings, which plausibly cover a large segment of equity markets
    - Improvement over models of bond markets only
    - Moreover, can differentiate between mutual funds of different styles (value, growth, etc)
- We wish to use this data to:
    - Test key predictions of the model
    - Improve identification in the (eventual) estimation of the model