Inflation Bets on the Long Bond

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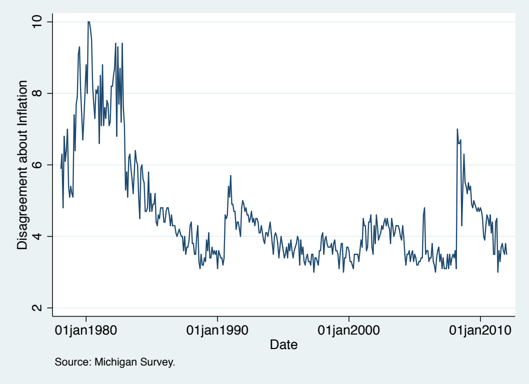
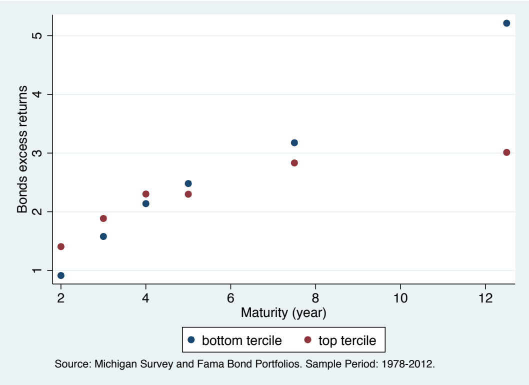
Inflation Uncertainty and Slope of Yield Curve

Mankiw, Reis and Wolfers '04: IQR of monthly Michigan Survey of US households' inflation expectations over next 12 months



Inflation Uncertainty and Slope of Yield Curve

IQR of Inflation Forecasts and Average Bond Portfolio Returns, 1978-2012



Puzzling in Light of Traditional Explanations

- Textbook explanations (liquidity preference, preferred habitat): slope of Treasury yield curve should, if anything, rise with inflation uncertainty
  - Aversion to liquidating when bond prices are low due to unexpected inflation
  - Liquidity concerns $\rightarrow$ tilt away from LT to ST
  - Demand risk premium which rises with maturity

Our Hypothesis: Inflation-Betting Effect

- Uncertainty = disagreement in inflation expectations among bond investors
- Prices of LT bonds more sensitive to inflation than ST ones
- Bond maturity magnifies disagreement in inflation expectations
- Differences in opinion and speculative demand (Varian '88, Kandel and Pearson '95, Harris and Raviv '93, Scheinkman and Xiong '93)
  - Optimists (expect low inflation) want to buy/long LT bonds
  - Pessimists (expect high inflation) want to sell/short LT bonds

Binding Short-Sales Constraints and Overpricing of LT Bonds

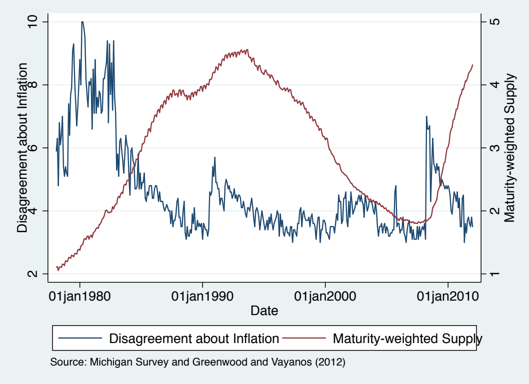
- But some pessimists are likely short-sales constrained.
  - Retail bond mutual funds, who own around 10% of the Treasury supply, do not short for institutional reasons (Almazan et.al '04, Koski and Pontiff '99)
  - Only one short Treasuries ETF with small amount of assets
- When disagreement is large relative to supply of Treasuries, long-term bonds more likely to be held by the most optimistic investors
- Over-pricing of long-term compared to the short-term bonds and a flatter yield curve

Identification Strategy: Inflation-Betting Effect Stronger when Aggregate Treasury Bond Supply is Low

- Embed inflation disagreement in an otherwise standard risk premia model of term structure of interest rates (Vayanos and Vila (2009))
- Shorting constraints more likely to bind when supply is low
  - Aggregate Treasury supply large: even pessimists are long due to limited risk absorption in market
  - Aggregate Treasury supply low: easier for all LT bonds to be held by optimists

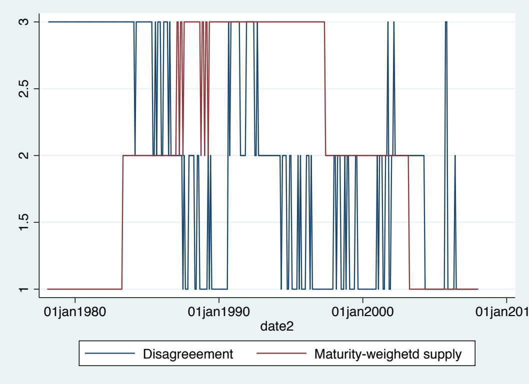
Aggregate Supply of Treasuries

Maturity-weighted-debt-to-GDP ratio from Greenwood and Vayanos '08: forecast Treasury bond returns and steeper yield curve



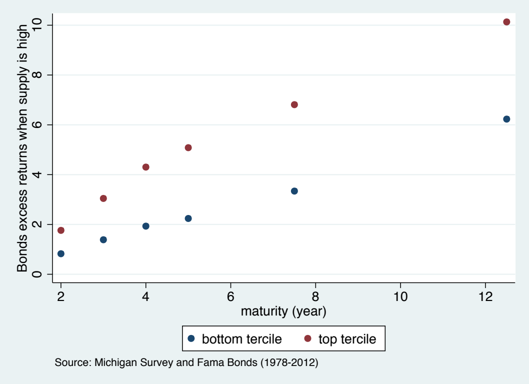
Inflation Disagreement x Aggregate Supply of Treasuries

Inflation Disagreement and Maturity-weighted-debt-to-GDP ratio



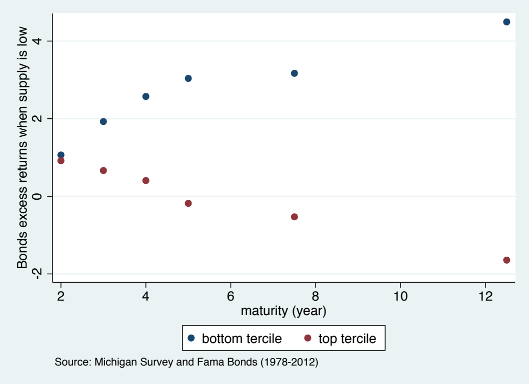
Inflation Disagreement and Yield Curve when High Supply

Inflation Disagreement and Maturity-weighted-debt-to-GDP ratio



Inflation Disagreement and Yield Curve when Low Supply

Inflation Disagreement and Maturity-weighted-debt-to-GDP ratio



Our Contribution

- Supply effects important in bond markets in a traditional risk absorption story (Greenwood and Vayanos '08, Greenwood, Hanson and Stein '08, Krishnamurthy and Vissing-Jorgensen '12)
- Inflation disagreement can lead to more volatility and lower yields even absent frictions (Xiong and Yan '10, Ehling et.al. '12, Buraschi et.al. '11)
- Our contribution is two-fold
  - (1) to focus on the disagreement and the shorting friction and how it flattens yield curve.
  - New identification strategy using Disagreement x Supply (Hong, Scheinkman and Xiong '06)

Model

- Extension of Vayanos and Vila (2007)
- OLG $t = 1, 2, \ldots t, \ldots, \infty$
- Mean variance preferences
- Generation-t investors are initially endowed at date t with an exogenous real wealth W_t.
- Call V_{t+1} their final real wealth, which equals their date-t+1 consumption.

Model: Disagreement about Inflation

- Call Π_t the price level at t.
- By definition: $\tilde{\Pi}_{t+1} = e^{\tilde{\pi}_{t+1}}\Pi_t$, i.e. $\tilde{\pi}_{t+1}$ is the log-growth rate of the price index.
- Inflation follows a random walk: $\tilde{\pi}_{t+1} = \pi_t + \tilde{\epsilon}_{t+1}$, where $\mathbb{E}[\tilde{\epsilon}_{t+1}] = 0$ and $Var[\epsilon_{t+1}] = \sigma_\epsilon^2$.
- Mass 1 of investors endowed with heterogeneous belief about the next period expected value of inflation: $\mathbb{E}^i[\tilde{\epsilon}_{t+1}] = \lambda^i$, $i \in (A, B)$.
- Investors A are optimists (i.e., $\lambda^A = -\lambda$) and investors B are pessimists ($\lambda^B = \lambda$).

Bonds and a Exogenous Real Asset

- Zero-coupon bonds w/ K different maturities and real asset with deterministic rate of return ρ
- Supply Q_t^k at date t for bonds of maturity k.
- Note $P_t^{(k)}$ the price of a bond maturing in k period at date t
- $x_{t,i}^{(k)}$ the number of bonds of maturity k held by investors in group i at date t.
- Cannot short bonds but can freely short the real asset.

Budget Constraint and Optimization Problem

- The date-t+1 real wealth of investors in group i is given by:

$$\tilde{V}^i_{t+1} = \frac{\sum_{k=2}^{K} x^{(k)}_{t,i} \tilde{P}^{(k-1)}_{t+1} + x^{(1)}_{t,i}}{\tilde{\Pi}_{t+1}} + \left(W_t - \frac{\sum_{k=1}^{K} x^{(k)}_{t,i} P^{(k)}_t}{\Pi_t} \right) (1+\rho)$$

- In what follows, we normalize ρ to 0 without loss of generality.
- We define the yield on a bond of maturity k at date t as: $ky^{(k)}_t = -\log\left(\tilde{P}^{(k)}_t\right)$.
- The optimal investment strategy of generation-t investors in group i is given by the following program:

$$\max_{\left(x^{(k)}_t\right)} \mathbb{E}_t[\tilde{V}^i_{t+1}] - \frac{1}{2\gamma} \mathrm{Var}_t[\tilde{V}^i_{t+1}]$$

Linear Equilibrium and First-Order Linear Approximation

- We first consider a steady-state equilibrium where investors from both groups are long all maturity.
- Furthermore, assume that in this equilibrium, the yield of a bond of maturity k at date t is given by:

$$\forall \tau \geq 0, \ \forall k \geq 1: \quad k y_{\tau}^{(k)} = a_k \pi_{\tau} + b_k$$

- Assume inflation rates are small on average so that we can use a linear approximation for:

$$e^{-(a_{k-1}+1)\tilde{\pi}_{t+1} - b_{k-1}} \approx 1 - b_{k-1} - (1 + a_{k-1})\tilde{\pi}_{t+1}$$

- Can rewrite the wealth next period as linear in yields

$$\tilde{V}_{t+1}^{i} = W_t + \frac{1}{\Pi_t}\left(\sum_{k=2}^{K} x_{t,i}^{(k)}\left(k y_t^{(k)} - b_{k-1} - (1 + a_{k-1})\tilde{\pi}_{t+1}\right) + x_{t,i}^{(1)}\left(y_t^{(1)} - \tilde{\pi}_{t+1}\right)\right)$$

Equilibrium w/ Non-binding Short-Sales Constraints

- When

$$\lambda < \frac{\sigma_\epsilon^2}{\gamma}\left(\sum_{k=1}^{K} k Q_t^{(k)}\right)$$

- Yields are given by:

$$y_t^{(k)} = \frac{a_k}{k}\pi_t + \frac{b_k}{k} = \pi_t + \frac{k+1}{2}\frac{\sigma_\epsilon^2}{\gamma}\left(Q_t^{(1)} + \sum_{l=2}^{K} l Q_t^{(l)}\right)$$

- Expected nominal log returns:

$$\mathbb{E}[\tilde{R}_t^{(k)}] = \mathbb{E}[\log\left(\tilde{P}_{t+1}^{(k-1)}\right)] - \log\left(P_t^{(k)}\right) = \pi_t + k\frac{\sigma_\epsilon^2}{\gamma}\left(\sum_{l=1}^{K} l Q_t^{(l)}\right)$$

- As σ_ϵ^2 increases, so does the slope of yield curve.

Equilibrium w/ Binding Short-Sales Constraints

- When

$$\lambda > \frac{\sigma_\epsilon^2}{\gamma}\left(\sum_{k=1}^{K} kQ_t^{(k)}\right)$$

- Yields are given by:

$$y_t^{(k)} = \pi_t + \frac{k+1}{2}\left(\frac{2\sigma_\epsilon^2}{\gamma}\left(\sum_{k=1}^{K} kQ_t^{(k)}\right) - \lambda\right)$$

- Expected nominal log returns:

$$\mathbb{E}[\tilde{R}_t^{(k)}] = \pi_t + k\left(\frac{2\sigma_\epsilon^2}{\gamma}\left(\sum_{k=1}^{K} kQ_t^{(k)}\right) - \lambda\right)$$

Data: Inflation Disagreement

- Michigan Survey of 600 household subjects (starting in 1978, monthly)
- Livingston Survey of economists and professionals (starting in 1950's, semi-annual)
- Mankiw, Reis and Wolfers '04: Michigan more accurate than Livingston

Data: Bond Prices

- CRSP Fama Bond Portfolios (starting in 1952, missing 10 years of 30 year bonds)
- CRSP Fixed Term Index (starting in 1940, single closest bond but not portfolio though very similar to CRSP Fama Bonds)
- Fed Data (has some matrix pricing but more maturities available)

Inflation Disagreement and Bond Returns: By Maturity

	Excess Returns					
	2 years	3 years	4 years	5 years	5/10 years	10+ years
$\text{Disagreement}_{t-1}$	-.027	-.25	-.47	-.7	-.97	-1.8*
	(-.13)	(-.71)	(-.99)	(-1.3)	(-1.3)	(-1.8)
CP Factor	.34***	.52***	.68***	.73***	1***	1.5**
	(3.8)	(3.5)	(3.3)	(2.8)	(2.7)	(2.3)
Constant	1	2.6	4*	5.3**	7**	12***
	(1.1)	(1.6)	(1.9)	(2.2)	(2.2)	(2.7)
Observations	407	407	407	407	407	407
R2	.18	.16	.16	.14	.16	.16

Interaction of Disagreement and Supply: By Maturity

	Excess Returns					
	2 years	3 years	4 years	5 years	5/10 years	10+ years
$\text{Dis.}_{t-1}.\text{Sup}_{t-1}$	.79***	1.4***	1.9***	2.2***	2.8***	3.5***
	(4)	(4.3)	(4.4)	(4.4)	(3.7)	(2.9)
Supply_{t-1}	-3***	-5.4***	-7.5***	-8.8***	-10***	-12**
	(-3.4)	(-3.7)	(-3.8)	(-3.7)	(-3.2)	(-2.4)
Dis._{t-1}	-1.3***	-2.6***	-3.8***	-4.6***	-5.6***	-7.3***
	(-2.9)	(-3.5)	(-3.8)	(-4)	(-3.5)	(-3.1)
Constant	5.9**	12***	17***	20***	24***	30***
	(2.4)	(2.9)	(3.2)	(3.3)	(3.1)	(2.7)
Observations	407	407	407	407	407	407
R2	.15	.16	.18	.18	.18	.15

Controlling for CP Factor: By Maturity

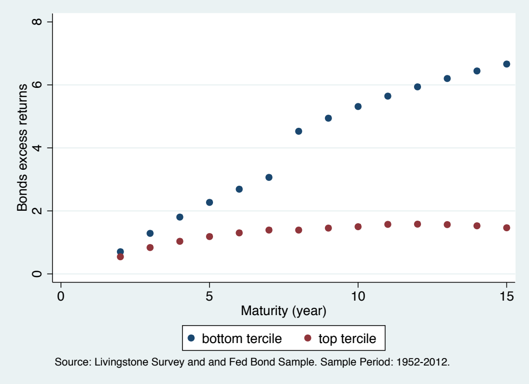
	Excess Returns					
	2 years	3 years	4 years	5 years	5/10 years	10+ years
Dis.$_{t-1}$.Sup$_{t-1}$	.62***	1.1***	1.6***	1.9***	2.4***	2.9***
	(4)	(4.4)	(4.7)	(4.6)	(4.2)	(3.5)
Supply$_{t-1}$	-2.6***	-4.7***	-6.7***	-8***	-9.4***	-11***
	(-3.4)	(-3.7)	(-3.9)	(-3.9)	(-3.5)	(-2.8)
Dis.$_{t-1}$	-1.2***	-2.4***	-3.5***	-4.4***	-5.3***	-7***
	(-3.2)	(-4)	(-4.4)	(-4.6)	(-4.4)	(-4.3)
CP Fact..Sup$_{t-1}$	-.11	-.15	-.22	-.28	-.46*	-.86*
	(-1.6)	(-1.4)	(-1.5)	(-1.5)	(-1.7)	(-1.7)
CP fact.	.57**	.82**	1.1**	1.3**	2**	3.4***
	(2.3)	(2.1)	(2.3)	(2.2)	(2.6)	(2.8)
Constant	6.1***	12***	17***	21***	25***	32***
	(2.7)	(3.2)	(3.5)	(3.7)	(3.6)	(3.4)
Observations	407	407	407	407	407	407
R2	.26	.26	.27	.26	.27	.25

Sub-Periods and Fed Bond Pricing Series

- Drop seventies: effects are significant at 11% level
- Drop various years in eighties: effects significant at 5% level
- Drop various years in nineties: effects significant at 3% level
- Drop 2005-2012: effects significant at 3% level
- Stronger results using Fed bond pricing series as matrix pricing gives more maturities than Fama bonds

Livingston Survey: 50's til now, semi-annual surveys

Qualitatively similar results but limited statistical significance.



Conclusion: Connection to Reaching for Yield

- Traditional story: low i-rates lead to a search for minimum yield and bearing duration risk or junk risk (Rajan '10, Taylor, Feldstein, Stein '13)
- Incentives of institutions or naivette of retail investors but silent on investor expectations (Becker and Ivashina '13)
- Uncertainty over the path of inflation + interest rates can lead to reach for yield
- Interesting to consider proxies for uncertainty or disagreement over interest rates as opposed to inflation