Dynamic Bond Portfolio Choice with Macroeconomic Information

Alexandros Kostakis (University of Glasgow) and
Peter Spencer (University of York)

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Outline

- Motivation and Related Literature

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- Contribution

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- Methodological issues

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- Hedging demand arises due to investor's desire to hedge against adverse shocks to the underlying state variables
- This issue becomes particularly important if returns are predictable

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- Commonly used predictors/ underyling stochastic factors: interest rate, dividend yield and Sharpe ratio
- But evidence on stock returns' predictability is rather weak (e.g. Goyal and Welch, 2008)
- On the other hand, bond yields are more reliably predictable by macroeconomic variables (Ang and Piazzesi, 2003)

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- Theoretical treatment: Wachter (2003), Liu (2007)

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- Explicitly utilize macroeconomic information for asset allocation (neglected in the literature)

- There are 5 macroeconomic factors -> examine portfolio choice among multiple bonds with different maturities

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- Evaluate the term structure model of Dewachter et al. (2006) from an asset allocation perspective

Risk factors

- Setup of Dewachter et al. (2006): 5 stochastically time-varying risk factors: output gap y, inflation rate π, real interest rate ρ, inflation central tendency π^* and central tendency of real interest rate ρ^*. Dynamics given by the following SDEs:

$$dy = [\kappa_{yy} y + \kappa_{y\pi}(\pi - \pi^*) + \kappa_{y\rho}(\rho - \rho^*)]dt + \sigma_y dw_y$$

$$d\pi = [\kappa_{\pi y} y + \kappa_{\pi\pi}(\pi - \pi^*) + \kappa_{\pi\rho}(\rho - \rho^*)]dt + \sigma_\pi dw_\pi$$

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- Collect them in $X = (y, \pi, \rho, \pi^*, \rho^*)$:

$$dX = [\bar{\psi} + KX]dt + Sdw$$

Bond returns dynamics

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- No-arbitrage pricing dictates that returns' dynamics of the zero-coupon bond i are given by:

$$\frac{dP_i}{P_i} = (r - b(\tau)^T S^2\Lambda - b(\tau)^T \Xi X)dt - b(\tau)^T S dw$$

Implications from estimated term structure model

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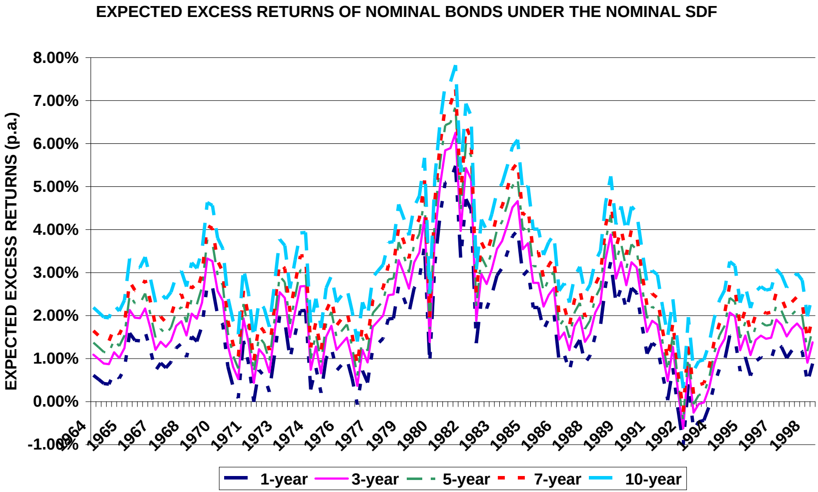
- Filtered series: inflation central tendency exhibits very low volatility and it is highly persistent
- Considerable time-variation + strong co-movement in bonds' expected returns (mainly via inflation central tendency). "Reasonable" premia wrt previous studies (e.g. Sangvinatsos and Wachter, 2005)

Bonds' expected excess returns



Bond returns' covariance and correlation structure

Panel A: Covariance Matrix						
	1-year	2-year	3-year	5-year	7-year	10-year
1-year	0.0004					
2-year	0.0007	0.0014				
3-year	0.0009	0.0019	0.0026			
5-year	0.0013	0.0026	0.0037	0.0054		
7-year	0.0016	0.0032	0.0046	0.0069	0.0088	
10-year	0.0019	0.0041	0.0058	0.0058	0.0115	0.0153
Panel B: Correlation Matrix						
	1-year	2-year	3-year	5-year	7-year	10-year
1-year	1					
2-year	0.974	1				
3-year	0.947	0.994	1			
5-year	0.897	0.964	0.987	1		
7-year	0.848	0.927	0.961	0.993	1	
10-year	0.782	0.871	0.916	0.968	0.991	1

- Very low variances at short maturities -> Very high Sharpe ratios. Extremely high correlation for near maturities.

Intertemporal portfolio choice

- Use the martingale methodology (Cox and Huang, 1989) to solve the intertemporal portfolio choice problem. The long-term investor maximizes power utility over REAL terminal wealth:

$$\max E_{t_0}\left\{\frac{\left(\frac{W_T}{\Pi_T}\right)^{1-\gamma}}{1-\gamma}\right\}, \qquad 0<\gamma\neq 1$$

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- Dynamics for price level process Π:

$$\frac{d\Pi}{\Pi} = \pi dt + \sigma_{\Pi}^{T} dw$$

Calculating the optimal portfolio

- Subject to conditions, optimal portfolio choice is given by:

$$\phi_t = \frac{1}{\gamma}(B^T S^2 B)^{-1}(-B^T S^2 \Lambda - B^T \Xi X_t)$$
$$+(1-\frac{1}{\gamma})(B^T S^2 B)^{-1}(-B^T S)\sigma_\Pi$$
$$+\frac{1}{\gamma}(B^T S^2 B)^{-1}(-B^T S)S[d(t) + \frac{1}{2}(Q(t) + Q(t)^T)X_t]$$

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- The remainder $\phi_0 = 1 - i^T \phi$ is invested in the nominal instantaneously riskless asset yielding the risk-free rate r

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- 2 interesting observations:

1. Hedging demand depends on the diffusion coeff of risk factors' dynamics as well as the sensitivity of investor's wealth to the risk factors, represented by $d(t)$ and $Q(t)$.
2. Both myopic and hedging bond demands induce market timing, i.e. portfolio choice depends on the current level of risk factors.

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- Methodological note: Incompleteness in our setup arises only due to the number of bonds
- When no. bonds$=$ no. risk factors-$>$ complete markets because inflation is an explicit risk factor (so shocks to price level process Π can be hedged too)

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- Returns' dynamics of real zero-coupon bond i given by:

$$\frac{dP_i^R}{P_i^R} = (r - \pi + \sigma_{\Pi}^{T}\xi - b^R(\tau)^T S\xi + b^R(\tau)^T S\sigma_{\Pi})dt - b^R(\tau)^T Sdw$$

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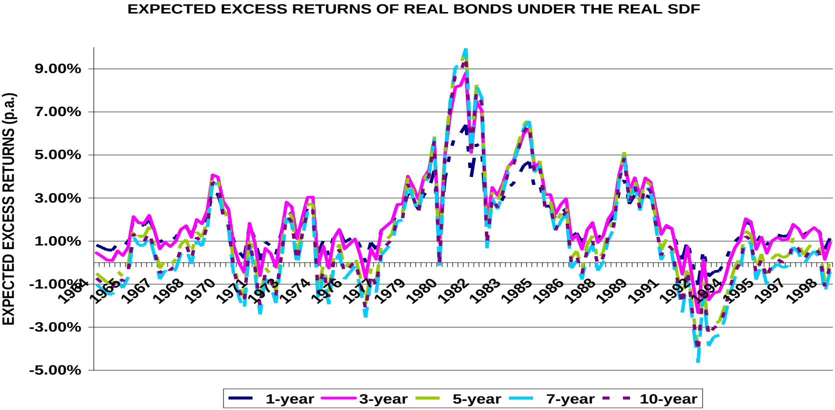
- Intertemporal portfolio choice problem among real or among nominal+ real bonds solved using the same techniques

Real bonds' excess returns



- Real bonds' excess returns turn negative (puzzling for myopic risk-averse investor). Significant time-variation+ strong co-movement

Portfolio choice among two nominal bonds

Panel A: Benchmark case 1975:Q1									
		γ=4				γ=10			
	Premia	T=0	T=3	T=5	T=10	T=0	T=3	T=5	T=10
3-yr	0.65%	0.05	5.17	4.66	1.94	0.03	3.79	3.88	2.01
10-yr	1.71%	0.26	0.29	1.28	3.12	0.10	0.02	0.63	2.12
Panel B: One St. dev. increase in inflation central tendency									
		γ=4				γ=10			
	Premia	T=0	T=3	T=5	T=10	T=0	T=3	T=5	T=10
3-yr	0.88%	0.84	9.39	8.77	5.47	0.35	6.07	6.13	3.82
10-yr	1.96%	0.002	-0.24	0.94	3.15	-0.004	-0.23	0.52	2.32
Panel C: One St. dev. decrease in inflation central tendency									
		γ=4				γ=10			
	Premia	T=0	T=3	T=5	T=10	T=0	T=3	T=5	T=10
3-yr	0.42%	-0.74	0.94	0.56	-1.59	-0.28	1.52	1.64	0.19
10-yr	1.46%	0.52	0.82	1.62	3.09	0.20	0.26	0.74	1.91

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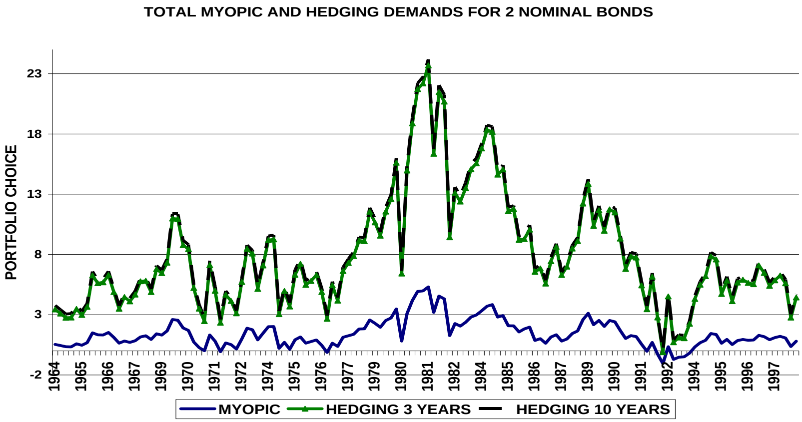
- Shifts in the macroeconomy (in particular inflation central tendency) affect bonds' premia and hence change myopic and hedging demands
- Allocation among bonds changes with investment horizon- investor attempts to combine bonds' maturities so as to match his investment horizon+ hedge shocks to his real wealth process

Sensitivity analysis (2 bonds, RRA=10, T=3 and 10 years)



- Implausibly high myopic and hedging demands due to high Sharpe ratios and extremely low variances of risk factors

Portfolio choice among three bonds

Panel A: Three nominal bonds (nominal SDF) 1975:Q1									
		γ=4				γ=10			
	Premia	**T=0**	**T=1**	**T=5**	**T=10**	**T=0**	**T=1**	**T=5**	**T=10**
1-yr (N)	**0.20%**	**1.74**	**0.73**	**-5.96**	**-3.89**	**0.14**	**-0.25**	**-5.77**	**-4.31**
5-yr (N)	**0.91%**	**-1.61**	**1.27**	**8.66**	**4.09**	**-0.27**	**1.53**	**8.08**	**4.74**
10-yr (N)	**1.71%**	**0.99**	**-0.07**	**-1.07**	**2.13**	**0.25**	**-0.42**	**-1.66**	**0.91**
Panel B: Three real bonds (real SDF) 1975:Q1									
		γ=4				γ=10			
	Premia	**T=0**	**T=1**	**T=5**	**T=10**	**T=0**	**T=1**	**T=5**	**T=10**
1-yr (R)	**0.34%**	**29.69**	**31.68**	**30.51**	**31.71**	**11.87**	**13.42**	**12.52**	**13.40**
5-yr (R)	**-1.37%**	**-12.96**	**-13.45**	**-15.90**	**-20.92**	**-5.18**	**-5.44**	**-6.64**	**-10.67**
10-yr (R)	**-1.59%**	**3.83**	**4.47**	**9.46**	**13.76**	**1.53**	**1.87**	**5.13**	**8.78**
Panel C: Three nominal and real bonds under the nominal SDF 1975:Q1									
		γ=4				γ=10			
	Premia	**T=0**	**T=1**	**T=5**	**T=10**	**T=0**	**T=1**	**T=5**	**T=10**
1-yr (N)	**0.20%**	**2.98**	**4.71**	**4.81**	**2.28**	**0.87**	**2.00**	**1.99**	**1.17**
5-yr (R)	**-0.84%**	**-1.42**	**-0.99**	**0.83**	**-0.37**	**-0.46**	**-0.14**	**1.08**	**0.63**
10-yr (N)	**1.71%**	**0.60**	**0.63**	**3.15**	**3.74**	**0.23**	**0.23**	**1.30**	**2.43**

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- Hedging demands are also extreme due to huge wealth sensitivities at low levels of RRA and long horizons
- Investor again combines bonds' maturities so as to match his horizon
- Real bonds useful for both diversification (lower correlation with nominal bonds) and hedging (better hedge against shocks to real wealth process)
- For the infinitely long-term risk averse investor with utility over real terminal wealth, the only *risk-free* asset is the zero-coupon bond whose maturity *matches* his horizon

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  + great hedging demands for a multi-period risk averse investor

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- Term structure models focus on fitting bond yields+ predicting premia. They neglect implied covariance structure of bond returns
- Serious failure from an asset allocation perspective because they imply extremely high risky assets' demands
- Parameter uncertainty potential way out
- Failure of the expectation hypothesis induces considerable market timing for a myopic investor
  + great hedging demands for a multi-period risk averse investor
- Macroeconomic information particularly important for bond investors -> incorporate it in portfolio choice context (e.g. the life-cycle model of Koijen et al. (2009))

Thank you for attending!