Yield Curve Premia

Brooks & Moskowitz (2017)

Gustavo Amarante

Carry, momentum and value provide rich description of bond return premia

- Subsume information from the yield curve's first three principal components, macroeconomic data and Cochrane and Piazzesi (2005, CP) factor
- Describes both the cross-section and time-series of yield curve premia across different countries
- Provide new economic intuition for what drives bond return premia
- Connects to return predictability in other asset classes, suggesting a unifying asset pricing framework

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4. Tradeable Bond Portfolios

Outline: International Bond Data and Yield Curves

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International Bond Data and Yield Curves

- **Zero Coupon Yields**
  - Australia, Germany, Canada, Japan, Sweden, UK and US.
  - Maturities from 1 to 30 years
  - Sources:
    - Wright (2011): From Dec 1971 to May 2009
    - Reuters (DSFI): From June 2009 to Mar 2016
- **Portfolios**
  - Level: 10-year
  - Slope: Long 10-year, Short 2-year, duration neutral
  - Butterfly: Long 5-year, short equal-duration weighted average of 2- and 10-year
- **Synthetic Returns**
  - Quarterly annualized log returns in excess of the 3-month yield.
- **Principal Components**
  - Computed using the full sample


Yields
Mean
Stdev
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
AU#01
AU#02
AU#03
AU#04
AU#05
AU#06
AU#07
AU#08
AU#09
AU#10
BD#01
BD#02
BD#03
BD#04
BD#05
BD#06
BD#07
BD#08
BD#09
BD#10
CN#01
CN#02
CN#03
CN#04
CN#05
CN#06
CN#07
CN#08
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JP#01
JP#02
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JP#04
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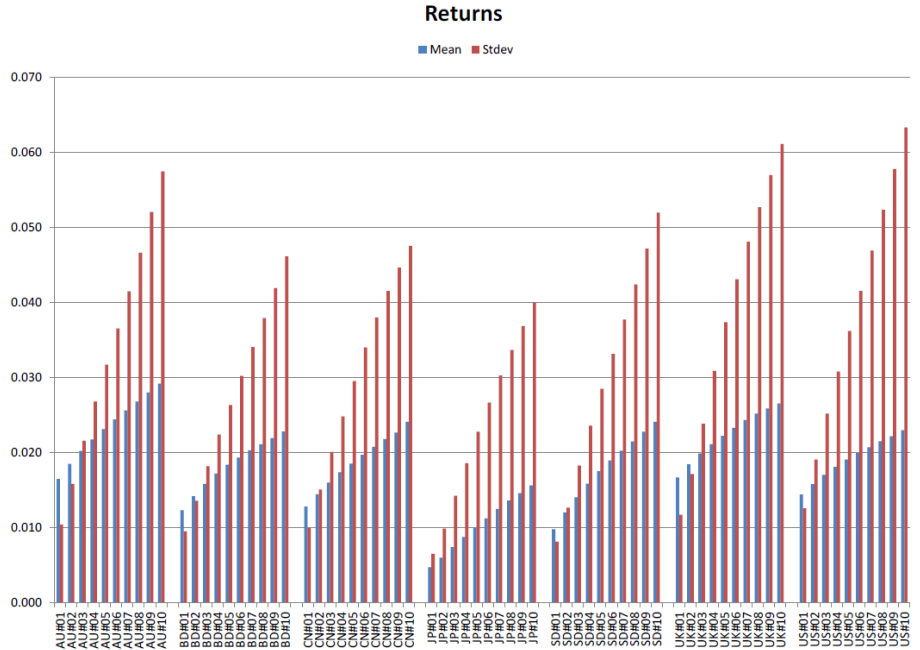
US#10


Returns
Mean
Stdev
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
AU#01
AU#02
AU#03
AU#04
AU#05
AU#06
AU#07
AU#08
AU#09
AU#10
BD#01
BD#02
BD#03
BD#04
BD#05
BD#06
BD#07
BD#08
BD#09
BD#10
CN#01
CN#02
CN#03
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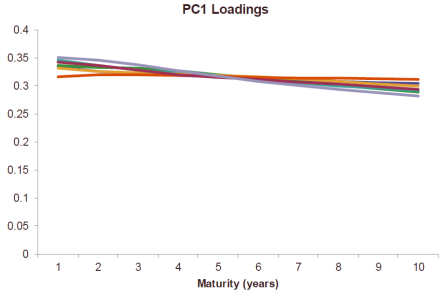
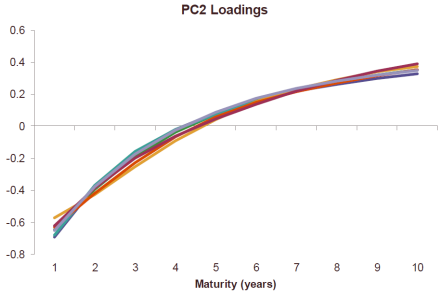
UK#09
UK#10
US#01
US#02
US#03
US#04
US#05
US#06
US#07
US#08
US#09
US#10

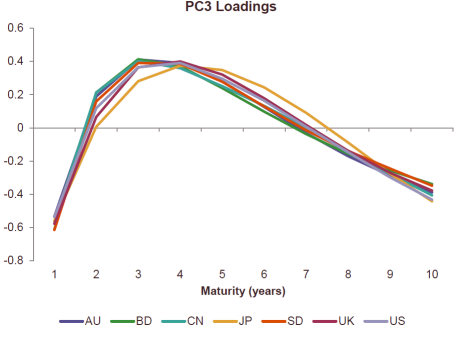
Table I: First Three Principal Components of Yields and Level, Slope, and Curvature Portfolios Across Countries

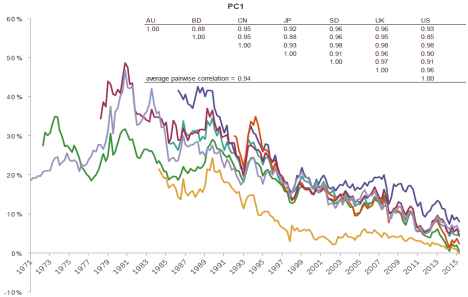
Panel A reports the fraction of the covariance matrix of yields across 1 to 10 year maturity zero coupon bonds in each country explained by each of the first three principal components, as well as the total amount of covariation explained by all three principal components. Panel B reports the correlation between the first principal component, PC1, and the yield on the "level" portfolio (10-year bond) for each country, the correlation between the second principal component, PC2, and the yield on the "slope" portfolio (10-year minus 2-year bond) in each country, and the correlation between the third principal component, PC3, and the yield on the curvature or butterfly portfolio (5-year minus an average of 10- and 2-year bonds) in each country.

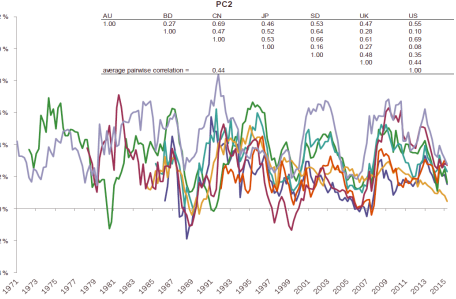
	AU	BD	CN	JP	SD	UK	US	Avg.
	Panel A: Percent of Covariation Captured by PCs							
PC1	97.6%	95.4%	96.7%	96.6%	97.8%	96.7%	96.8%	96.8%
PC2	1.9%	3.8%	2.5%	2.9%	1.6%	2.7%	2.7%	2.6%
PC3	0.4%	0.5%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
Total	99.9%	99.7%	99.7%	99.9%	99.9%	99.8%	99.9%	99.8%
	Panel B: Correlation between PC and Level, Slope, and Butterfly Portfolios							
PC1, Level	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
PC2, Slope	0.98	0.96	0.92	0.98	0.98	0.91	0.84	0.94
PC3, Butterfly	0.81	0.73	0.73	0.89	0.96	0.98	0.84	0.85

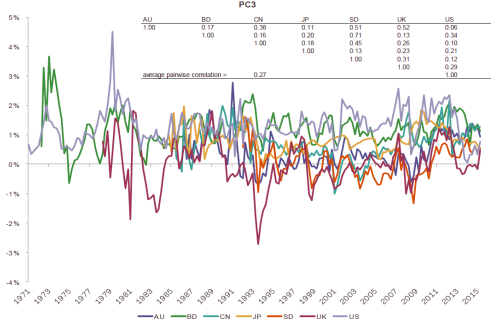

PC1 Loadings
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1 2 3 4 5 6 7 8 9 10
Maturity (years)


PC2 Loadings
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
1 2 3 4 5 6 7 8 9 10
Maturity (years)


PC3 Loadings
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
1 2 3 4 5 6 7 8 9 10
Maturity (years)
AU
BD
CN
JP
SD
UK
US


PC1
AU BD CN JP SD UK US
1.00 0.88 0.95 0.92 0.96 0.96 0.93
1.00 0.95 0.88 0.96 0.95 0.85
1.00 0.93 0.98 0.98 0.98
1.00 0.91 0.96 0.90
1.00 0.97 0.91
1.00 0.96
1.00
average pairwise correlation = 0.94
60 %
50 %
40 %
30 %
20 %
10 %
0 %
-10 %
1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015


PC2
AU BD CN JP SD UK US
1.00 0.27 0.69 0.46 0.53 0.47 0.55
1.00 0.47 0.52 0.64 0.28 0.10
1.00 0.53 0.66 0.61 0.69
1.00 0.16 0.27 0.08
1.00 0.48 0.35
1.00 0.44
1.00
average pairwise correlation = 0.44
12 %
10 %
8 %
6 %
4 %
2 %
0 %
-2 %
-4 %
1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015


PC3
AU BD CN JP SD UK US
1.00 0.17 0.38 0.11 0.51 0.52 0.06
1.00 0.16 0.20 0.71 0.13 0.34
1.00 0.18 0.45 0.26 0.10
1.00 0.13 0.23 0.21
1.00 0.31 0.12
1.00 0.29
1.00
average pairwise correlation = 0.27
5 %
4 %
3 %
2 %
1 %
0 %
-1 %
-2 %
-3 %
-4 %
1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
AU BD CN JP SD UK US

Outline: Cross-Section and Time-Series of Yield Curve Premia

1. International Bond Data and Yield Curves
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3. Spanned and Unspenned Sources of Returns
4. Tradeable Bond Portfolios

$$rx_{t+1}^{Level} = B' PC_t + S' \left[Carry_t \; Mom_t \; Val_t \right] + TimeFE + \varepsilon_{t+1}$$

$$\begin{aligned} Carry_t &= y_t^{10y} - y_t^{3m} \\ Mom_t &= ret_{t-12,t-1}^{10y} \\ Val_t &= y_t^{10y} - E_t \left(\pi_{t+1,t+10} \right) \end{aligned}$$

Cross-Section and Time-Series of Yield Curve Premia

Cross Section of the Level Portfolio Returns

	Panel A: Excess returns of country levels											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
PC1	0.089					0.039	0.075	0.111	0.029	0.063	0.099	0.055
	(2.63)					(1.05)	(2.37)	(3.01)	(0.85)	(1.65)	(2.79)	(1.49)
PC2	0.254					0.226	0.286	0.015	0.250	0.031	0.024	0.027
	(2.42)					(2.17)	(2.70)	(0.08)	(2.44)	(0.18)	(0.15)	(0.16)
PC3	-0.066					-0.044	-0.084	-0.228	-0.062	-0.174	-0.258	-0.207
	(-0.31)					(-0.21)	(-0.43)	(-0.90)	(-0.32)	(-0.71)	(-1.15)	(-0.93)
Carry				0.246	0.304			0.333		0.279	0.367	0.318
				(2.11)	(2.64)			(1.75)		(1.55)	(1.93)	(1.70)
Mom			-0.001		-0.021		-0.013		-0.019		-0.015	-0.019
			(-0.03)		(-0.98)		(-0.63)		(-0.92)		(-0.74)	(-0.91)
Val		0.525			0.498	0.439			0.466	0.380		0.401
		(3.56)			(3.72)	(2.61)			(3.12)	(2.45)		(2.88)
R^2 after F.E.	3.2%	3.7%	0.0%	1.0%	5.3%	5.1%	3.2%	3.9%	5.4%	5.6%	4.1%	6.1%
p-value of nested F-test versus (1)						(0.000)	(0.499)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)

$$rx_{t+1}^{Slope} = B' PC_t + S^{'} \left[Carry_t \; Mom_t \; Val_t \right] + TimeFE + \varepsilon_{t+1}$$

$$Carry_t = \frac{D}{10} \left(y_t^{10y} - y_t^{3m} \right) - \frac{D}{2} \left(y_t^{2y} - y_t^{3m} \right)$$
$$Mom_t = \frac{D}{10} \left(ret_{t-12,t-1}^{10y} \right) - \frac{D}{2} \left(ret_{t-12,t-1}^{2y} \right)$$
$$Val_t = \left(y_t^{10y} - E_t \left(\pi_{t+1,t+10} \right) \right) - \left(y_t^{2y} - E_t \left(\pi_{t+1,t+2} \right) \right)$$

Cross-Section and Time-Series of Yield Curve Premia

Cross Section of the Slope Portfolio Returns

	Panel B: Excess returns of country slopes											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
PC1	0.026					0.077	0.029	-0.014	0.068	0.019	-0.004	0.019
	(0.87)					(2.35)	(0.93)	(-0.49)	(2.11)	(0.64)	(-0.14)	(0.62)
PC2	0.205					-0.634	0.172	0.354	-0.574	-0.072	0.227	-0.109
	(1.89)					(-3.00)	(1.36)	(3.37)	(-2.79)	(-0.33)	(1.91)	(-0.49)
PC3	0.069					-0.370	0.061	0.265	-0.310	0.003	0.169	-0.018
	(0.26)					(-1.38)	(0.22)	(1.11)	(-1.14)	(0.01)	(0.68)	(-0.07)
Carry				0.265	0.277			0.292		0.259	0.307	0.269
				(5.52)	(6.21)			(6.07)		(5.49)	(6.10)	(5.51)
Mom			-0.027		-0.036		-0.009		0.004		-0.053	-0.036
			(-1.18)		(-1.54)		(-0.37)		(0.15)		(-2.17)	(-1.49)
Val		0.620			0.533	1.828			1.712	0.843		0.756
		(2.86)			(2.43)	(3.73)			(3.56)	(1.79)		(1.60)
R^2 after F.E.	0.9%	1.9%	0.3%	9.5%	10.4%	3.7%	0.9%	11.7%	3.3%	11.2%	11.7%	10.4%
p-value of nested F-test versus (1)						(0.000)	(0.938)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

$$rx_{t+1}^{Fly} = B' PC_t + S' \left[Carry_t \; Mom_t \; Val_t \right] + TimeFE + \varepsilon_{t+1}$$

$$Carry_t = \frac{D}{5}\left(y_t^{5y} - y_t^{3m}\right) - \frac{1}{2}\sum_{n\in\{2,10\}} \frac{D}{n}\left(y_t^{ny} - y_t^{3m}\right)$$

$$Mom_t = \frac{D}{5}\left(ret_{t-12,t-1}^{5y}\right) - \frac{1}{2}\sum_{n\in\{2,10\}} \frac{D}{n}\left(ret_{t-12,t-1}^{ny}\right)$$

$$Val_t = \left(y_t^{5y} - E_t\left(\pi_{t+1,t+5}\right)\right) - \frac{1}{2}\sum_{n\in\{2,10\}} \left(y_t^{ny} - E_t\left(\pi_{t+1,t+n}\right)\right)$$

Cross-Section and Time-Series of Yield Curve Premia

Cross Section of the Butterfly Portfolio Returns

	Panel C: Excess returns of country butterfly spreads											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
PC1	0.003					-0.001	0.005	-0.005	-0.002	-0.006	0.000	-0.003
	(0.35)					(-0.11)	(0.55)	(-0.51)	(-0.26)	(-0.69)	(-0.02)	(-0.39)
PC2	0.042					-0.056	0.047	0.024	-0.052	-0.072	0.018	-0.051
	(1.03)					(-1.30)	(1.13)	(0.63)	(-1.17)	(-1.69)	(0.47)	(-1.12)
PC3	0.414					-0.025	0.381	0.353	-0.025	-0.068	0.250	-0.031
	(3.02)					(-0.20)	(2.99)	(3.00)	(-0.19)	(-0.59)	(2.75)	(-0.25)
Carry				0.336	0.320			0.298		0.280	0.378	0.319
				(3.63)	(3.07)			(4.10)		(3.62)	(4.02)	(3.12)
Mom			-0.061		-0.033		-0.029		0.042		-0.088	-0.026
			(-1.66)		(-0.91)		(-0.99)		(1.41)		(-2.47)	(-0.63)
Val		2.973			2.207	3.096			3.316	2.922		2.417
		(4.29)			(4.78)	(4.55)			(4.87)	(4.61)		(3.49)
R^2 after F.E.	6.3%	11.4%	1.2%	7.6%	16.1%	11.8%	6.5%	11.9%	11.7%	16.5%	14.4%	16.5%
p-value of nested F-test versus (1)						(0.000)	(0.082)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

The same study is done using country fixed effects:

$$rx_{t+1}^{portfolio} = B' PC_t + S' \left[Carry_t \; Mom_t \; Val_t \right] + CountryFE + \varepsilon_{t+1}$$

- **Results are roughly the same:**
  - Time variation in country level returns appears to be related to the first two PCs, but even more strongly related to carry and value, which subsumes pricing information from the PCs.
  - Factors that drive the cross-section of expected yield curve returns also capture time-variation in expected returns

Outline: Spanned and Unspenned Sources of Returns

1. International Bond Data and Yield Curves
2. Cross-Section and Time-Series of Yield Curve Premia
3. Spanned and Unspenned Sources of Returns
   - How Are Styles Related to Yield Principal Components?
   - Are Styles Related to Information in Past Yields?
   - Unspanned Macro Factors
   - Cochrane and Piazzesi Factor
4. Tradeable Bond Portfolios

Spanned and Unspenned Sources of Returns

The style characteristics capture cross-sectional and time-series pricing information from the PCs (which fully characterize the yield curve) and have **additional** predictive power.

What is the nature of this additional information?

Spanned and Unspenned Sources of Returns

How Are Styles Related to Yield Principal Components?

Factor	Time Fixed Effects PC1	PC2	PC3	R^2	Country Fixed Effects PC1	PC2	PC3	R^2
Panel A: Level of yield curve								
Carry	-0.07	0.72	0.48	59.3%	-0.05	0.80	1.13	75.1%
	(-6.17)	(28.24)	(7.47)		(-10.97)	(35.98)	(10.71)	
Mom	-0.12	1.36	1.16	8.9%	-0.30	2.41	-0.71	14.9%
	(-2.06)	(7.09)	(3.89)		(-3.54)	(6.84)	(-0.78)	
Val	0.10	0.06	-0.03	17.7%	0.14	0.24	0.84	44.9%
	(8.16)	(1.73)	(-0.55)		(11.87)	(6.12)	(5.71)	
Panel B: Slope of yield curve								
Carry	0.14	-0.51	-0.66	6.8%	0.05	-0.33	-3.57	29.4%
	(2.96)	(-4.43)	(-2.27)		(2.57)	(-3.52)	(-8.06)	
Mom	0.08	-2.27	-1.78	25.5%	0.00	-3.13	-4.23	40.7%
	(1.82)	(-12.46)	(-5.75)		(0.05)	(-14.26)	(-8.13)	
Val	-0.03	0.45	0.25	82.8%	-0.03	0.55	0.17	96.3%
	(-13.57)	(58.47)	(15.50)		(-36.71)	(167.71)	(13.63)	
Panel C: Curvature of yield curve								
Carry	0.03	0.06	0.21	5.2%	0.01	0.12	-0.37	10.3%
	(2.34)	(2.17)	(2.65)		(2.48)	(4.90)	(-3.11)	
Mom	0.04	-0.07	-0.78	7.4%	-0.01	0.13	-2.45	40.8%
	(2.48)	(-1.10)	(-6.38)		(-1.39)	(2.45)	(-17.78)	
Val	0.00	0.03	0.14	55.2%	0.00	0.03	0.22	83.6%
	(0.11)	(10.21)	(26.74)		(13.85)	(12.57)	(37.45)	

Styles are related to the PCs but are not fully captured by them and add incremental explanatory power for returns.

One possible explanation is that the PCs indicate how yields are today, but not how rates have **recently changed** or how they compare to a **fundamental anchor**.

Spanned and Unspenned Sources of Returns

Are Styles Related to Information in Past Yields?

	Panel A: PCs from lagged yield curves					
	Level Portfolios		Slope Portfolios		Curvature Portfolios	
PC1	0.22	0.30	0.11	0.23	0.03	0.05
	(2.59)	(1.34)	(1.40)	(2.98)	(1.23)	(2.20)
$PC1_{t-1}$	-0.12	-0.17	-0.14	-0.19	-0.01	-0.02
	(-1.40)	(-0.75)	(-1.64)	(-2.19)	(-0.26)	(-0.98)
$PC1_{t-5}$	-0.04	-0.09	0.02	0.00	-0.04	-0.04
	(-0.82)	(-1.69)	(0.36)	(0.06)	(-2.17)	(-2.58)
PC2	0.29	-0.05	0.34	-0.39	0.01	-0.11
	(1.85)	(-0.23)	(2.39)	(-1.03)	(0.26)	(-2.07)
$PC2_{t-1}$	0.06	0.01	-0.14	0.13	0.04	0.09
	(0.39)	(0.03)	(-1.18)	(0.45)	(0.88)	(1.83)
$PC2_{t-5}$	0.01	0.03	-0.05	0.04	0.02	0.04
	(0.05)	(0.28)	(-0.55)	(0.37)	(0.52)	(1.25)
PC3	-0.001	-0.32	-0.31	-0.46	0.47	-0.05
	(-0.002)	(-1.06)	(-0.92)	(-1.43)	(3.55)	(-0.45)
$PC3_{t-1}$	0.06	0.15	0.35	0.30	-0.08	0.04
	(0.23)	(0.58)	(1.47)	(1.29)	(-1.05)	(0.32)
$PC3_{t-5}$	0.04	0.22	0.49	0.46	-0.04	-0.01
	(0.17)	(0.91)	(2.21)	(2.07)	(-0.49)	(-0.18)
Carry		0.49		0.22		0.35
		(1.92)		(2.64)		(3.09)
Mom		0.03		-0.02		0.01
		(0.42)		(-0.38)		(0.16)
Val		0.40		1.35		2.61
		(2.40)		(2.74)		(4.48)
R^2	4.3%	7.8%	3.2%	9.0%	7.3%	16.7%
p-value		(0.089)		(0.003)		(0.000)

	Panel B: Moving averge of PCs from lagged yield curves					
	Level Portfolios		Slope Portfolios		Curvature Portfolios	
PC1	0.40	0.47	0.23	0.34	-0.01	0.02
	(2.82)	(2.69)	(1.58)	(2.46)	(-0.12)	(0.44)
$PC1_{MA(1year)}$	-0.23	-0.23	-0.21	-0.23	0.05	0.03
	(-1.37)	(-1.21)	(-1.30)	(-1.52)	(0.97)	(0.66)
$PC1_{MA(5years)}$	-0.12	-0.21	-0.04	-0.06	-0.06	-0.07
	(-1.64)	(-2.76)	(-0.79)	(-1.26)	(-2.51)	(-3.14)
PC2	-0.06	-0.30	0.62	-0.31	0.06	-0.11
	(-0.21)	(-1.04)	(2.03)	(-0.78)	(0.65)	(-1.11)
$PC2_{MA(1year)}$	0.57	0.41	-0.45	-0.16	-0.06	0.04
	(1.87)	(1.42)	(-1.32)	(-0.41)	(-0.52)	(0.36)
$PC2_{MA(5years)}$	-0.17	-0.13	0.09	0.27	0.03	0.07
	(-1.32)	(-0.98)	(0.63)	(1.68)	(0.65)	(1.59)
PC3	-0.447	-0.74	-0.23	-0.36	0.82	0.25
	(-0.925)	(-1.55)	(-0.32)	(-0.54)	(3.68)	(1.36)
$PC3_{MA(1year)}$	0.40	0.33	0.01	-0.07	-0.44	-0.28
	(0.73)	(0.60)	(0.02)	(-0.11)	(-2.21)	(-1.49)
$PC3_{MA(5years)}$	0.25	0.60	0.93	0.84	-0.15	-0.03
	(0.78)	(1.83)	(2.91)	(2.45)	(-1.43)	(-0.30)
Carry		0.48		0.21		0.32
		(2.08)		(2.98)		(3.22)
Mom		0.03		-0.01		0.02
		(0.95)		(-0.24)		(0.58)
Val		0.41		1.58		2.40
		(2.51)		(2.90)		(3.95)
R^2	5.9%	9.5%	3.2%	9.4%	9.6%	17.5%
p-value		(0.000)		(0.003)		(0.000)

Styles maintain their predictive power even in the presence of lagged yield information.

Carry and Value remain statistically significant and with similar magnitudes as estimated before.

- **Macroeconomic Data**
  - Source: Consensus Economics (starting in 1990)
  - Expected inflation
  - Expected output growth (industrial production)

- **Cochrane-Piazzesi Factor**
  - Tent-shaped linear combination of forward rates
  - Can predict returns across maturities
  - Not spanned by the first three principal components of the yield curve

	Panel A: Level			Panel B: Slope			Panel C: Curvature		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Growth	-0.010	-0.050	-0.100	0.010	0.004	0.067	-0.032	-0.033	-0.014
	(-0.14)	(-0.75)	(-1.48)	(0.18)	(0.08)	(1.18)	(-1.61)	(-1.60)	(-0.62)
Inflation	-0.035	-0.260	-0.071	0.018	-0.019	-0.010	0.022	-0.004	0.068
	(-0.40)	(-2.74)	(-1.32)	(0.24)	(-0.20)	(-0.11)	(0.77)	(-0.16)	(2.54)
PC1		0.140	0.083		0.024	0.013		0.002	-0.017
		(3.82)	(2.06)		(0.69)	(0.38)		(0.17)	(-1.69)
PC2		0.244	-0.012		0.190	-0.055		0.046	-0.059
		(2.34)	(-0.07)		(1.75)	(-0.25)		(1.11)	(-1.30)
PC3		-0.058	-0.245		0.079	0.021		0.416	-0.071
		(-0.27)	(-1.07)		(0.30)	(0.08)		(2.99)	(-0.57)
Carry			0.367			0.279			0.313
			(1.94)			(5.48)			(3.04)
Mom			-0.021			-0.038			-0.025
			(-1.02)			(-1.58)			(-0.62)
Val			0.357			0.645			2.710
			(2.35)			(1.41)			(3.87)
R2	0.04%	4.32%	6.57%	0.01%	0.82%	10.67%	0.58%	6.69%	17.30%
p-value of nested F-test		(0.000)	(0.000)		(0.065)	(0.000)		(0.000)	(0.000)
		vs (1)	vs (2)		vs (1)	vs (2)		vs (1)	vs (2)

Macro factors have no predictive power at explaining slope and curvature returns with or without the PCs.

Carry and Value continue to capture significant positive return premia

Spanned and Unspenned Sources of Returns

Cochrane-Piazzesi Factor

Dependent variable = 10-year bond excess return, $rx_{t+1}^{(10)}$

CP	1.53	1.82	0.90	1.69	1.27	0.71	0.52
	(5.22)	(2.09)	(1.04)	(1.83)	(1.29)	(1.37)	(0.48)
PC1		-0.08	-0.16	-0.09	0.03		-0.14
		(-0.55)	(-1.11)	(-0.62)	(0.20)		(-0.73)
PC2		-0.26	0.71	0.27	-0.38		1.24
		(-0.23)	(0.62)	(0.22)	(-0.34)		(1.03)
PC3		-0.45	0.53	-0.05	-0.30		1.01
		(-0.29)	(0.32)	(-0.03)	(-0.19)		(0.58)
Val			1.30			0.95	1.36
			(2.70)			(2.05)	(2.49)
Mom				-0.17		-0.16	-0.19
				(-2.30)		(-2.38)	(-2.68)
Carry					0.95	1.34	0.37
					(1.25)	(1.91)	(0.41)
Intercept	-1.98%	-1.39%	-1.63%	-0.88%	-1.63%	-1.60%	-0.96%
	(-1.48)	(-0.67)	(-0.78)	(-0.42)	(-0.78)	(-1.03)	(-0.45)
R^2	12.25%	12.50%	16.21%	16.51%	13.03%	19.23%	20.18%

A simple value metric prices bonds better the CP factor or PCs.

Outline: Tradeable Bond Portfolios

1. International Bond Data and Yield Curves
2. Cross-Section and Time-Series of Yield Curve Premia
3. Spanned and Unspenned Sources of Returns
4. Tradeable Bond Portfolios
   - Style Performance
   - Style Factors in Other Asset Classes

- **Tradeable Bond Universe**
  - Source: JP Morgan Government Bond Index (GBI)
  - Country-Maturity Partitions: 1-5 years, 5-10 years and 10-30 years.
- **Country Porfolios**
  - Level: Equal-Duration across the partitions
  - Slope: Level-neutral, duration-weighted
  - Butterfly: Zero-duration, minimal slope exposure
- **Combined Portfolio**
  - Same definitions of carry, momentum and value as before
  - Countries are ranked by the style and weighted as

$$w_t = \frac{rank\,(style) - avg\,(rank)}{std\,(rank)}$$

  - Multi-style/single-dimension and single-style/multi-dimension, scaled to have equal vol contributions to a 10% vol portfolio (in sample)

Panel D: Multi-dimension returns

	Value	Momentum	Carry	Multi-style		PC1	PC2	PC3	Combo
Average	6.14%	2.11%	8.07%	9.67%		-0.29%	1.90%	0.13%	0.73%
Stdev	6.5%	6.2%	7.4%	7.3%		5.3%	5.4%	6.9%	5.7%
t-stat	4.4	1.6	5.0	6.1		-0.2	1.6	0.1	0.6
Sharpe	0.95	0.34	1.09	1.32		-0.05	0.35	0.02	0.13
Correl to market	0.08	0.17	0.15	0.22		0.03	0.25	0.07	0.17
Alpha to market	5.65%	1.03%	6.95%	8.05%		-0.45%	0.52%	-0.37%	-0.24%
t-stat	3.8	0.7	4.2	5.0		-0.4	0.4	-0.2	-0.2
Info ratio	0.87	0.17	0.95	1.13		-0.08	0.10	-0.05	-0.04
Skewness	1.34	0.03	1.62	2.71		-0.48	0.67	0.35	-1.19
Kurtosis	7.3	3.5	14.2	21.7		5.5	4.9	11.1	13.9
Autocorrelation	-0.05	0.01	0.03	0.02		-0.10	-0.17	-0.06	-0.19
Beta to PC1	0.21	-0.27	-0.32	-0.22	Beta to Carry	-0.34	-0.05	0.25	-0.16
	(3.89)	(-4.57)	(-5.50)	(-3.69)		(-5.68)	(-0.76)	(3.88)	(-2.75)
Beta to PC2	0.39	-0.02	0.08	0.22	Beta to Mom	-0.13	0.08	-0.21	-0.15
	(7.11)	(-0.28)	(1.42)	(3.76)		(-2.07)	(1.33)	(-3.24)	(-2.52)
Beta to PC3	0.23	-0.18	0.24	0.17	Beta to Val	0.29	0.45	0.16	0.45
	(4.33)	(-3.08)	(4.19)	(2.87)		(4.79)	(7.20)	(2.44)	(7.65)
Alpha to PCs	**8.20%**	**3.35%**	**10.38%**	**12.29%**	**Alpha to Styles**	**0.84%**	**-0.53%**	**-3.26%**	**-0.77%**
	(4.38)	**(1.62)**	**(5.14)**	**(5.95)**		**(0.40)**	**(-0.25)**	**(-1.49)**	**(-0.38)**

Style factors provide a direct connection to asset pricing factors used in other asset classes. **The efficacy and consistency of the concepts of carry, momentum and value in pricing an array of diverse assets suggests a *unifying framework* for pricing assets generally.**

	EQ value	FX value	Com value	Mkt-rf	Alpha	Marginal R^2
Panel A: Value						
Level value	0.28	0.23	-0.01	0.46	**0.33%**	13.0%
	(4.69)	(3.96)	(-0.09)	(2.38)	**(1.87)**	
Slope value	-0.03	0.05	-0.02	-0.15	**0.38%**	0.3%
	(-0.42)	(0.74)	(-0.31)	(-0.73)	**(2.01)**	
Butterfly value	0.06	-0.09	0.00	0.20	**0.61%**	1.1%
	(0.95)	(-1.34)	(0.07)	(0.97)	**(3.19)**	
Multi-dimension value	0.16	0.10	-0.01	0.26	**0.68%**	3.5%
	(2.55)	(1.61)	(-0.17)	(1.28)	**(3.62)**	
Panel B: Momentum						
	EQ mom	FX mom	Com mom	Mkt-rf	Alpha	Marginal R^2
Level mom	0.12	0.21	0.18	0.28	**0.10%**	10.9%
	(1.91)	(3.34)	(3.00)	(1.43)	**(0.56)**	
Slope mom	0.00	0.06	0.04	0.59	**0.04%**	0.5%
	(-0.06)	(0.88)	(0.63)	(2.85)	**(0.21)**	
Butterfly mom	0.01	-0.08	0.03	0.19	**-0.01%**	0.8%
	(0.13)	(-1.29)	(0.48)	(0.93)	**(-0.04)**	
Multi-dimension mom	0.07	0.10	0.13	0.57	**0.07%**	3.8%
	(1.04)	(1.51)	(2.18)	(2.81)	**(0.39)**	
Panel C: Carry						
	EQ carry	FX carry	Com carry	Mkt-rf	Alpha	Marginal R^2
Level carry	0.15	0.30	-0.06	0.30	**0.29%**	12.5%
	(2.57)	(5.11)	(-0.97)	(1.48)	**(1.56)**	(0.00)
Slope carry	0.11	0.08	-0.05	0.40	**0.44%**	2.2%
	(1.71)	(1.34)	(-0.79)	(1.90)	**(2.31)**	(0.13)
Butterfly carry	-0.02	-0.01	0.11	0.38	**0.82%**	1.2%
	(-0.35)	(-0.14)	(1.69)	(1.76)	**(4.25)**	(0.40)
Multi-dimension carry	0.11	0.17	0.00	0.48	**0.70%**	4.3%
	(1.73)	(2.75)	(-0.00)	(2.32)	**(3.69)**	(0.01)

Tradeable Bond universe

Style Factors in Other Asset Classes

	EQVOL	FIVOL	GBI	HY	OTR	SPX	Alpha	R^2
Level multi-style	-0.02	0.69	0.95	0.10	-1.41	0.10	0.58%	5.4%
	(-0.06)	(0.60)	(4.05)	(1.14)	(-0.58)	(1.91)	(2.87)	
Slope multi-style	0.32	2.17	0.59	0.10	3.01	0.02	0.27%	4.6%
	(0.83)	(1.84)	(2.48)	(1.08)	(1.21)	(0.32)	(1.28)	
Butterfly multi-style	-0.05	0.33	0.87	0.33	-2.06	-0.07	0.81%	6.9%
	(-0.12)	(0.29)	(3.73)	(3.79)	(-0.85)	(-1.30)	(3.99)	
Multi-dimension value	0.23	0.09	0.48	0.13	-3.02	0.07	0.63%	6.0%
	(0.63)	(0.08)	(2.08)	(1.48)	(-1.26)	(1.38)	(3.16)	
Multi-dimension mom	-0.05	1.11	0.56	0.01	-0.77	0.00	0.15%	0.5%
	(-0.14)	(0.97)	(2.42)	(0.09)	(-0.32)	(0.09)	(0.72)	
Multi-dimension carry	0.06	1.60	0.91	0.28	3.03	-0.03	0.58%	8.2%
	(0.15)	(1.41)	(3.92)	(3.28)	(1.26)	(-0.58)	(2.88)	
Multi-dimension, multi-style	0.12	1.46	1.10	0.24	-0.21	0.02	0.76%	7.8%
	(0.31)	(1.28)	(4.78)	(2.79)	(-0.09)	(0.44)	(3.79)	

Conclusions

- **These simple style factors**:
  - do significantly better job explaining yield curve returns than a combination of traditional yield factors and other unspanned factors.
  - provide economic intuition for what drives yield curve premia.
  - offer an enticing and direct link to return predictability from other asset classes.