Treasury Yield Implied Volatility and Real Activity

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Research question:

- What information from financial markets predicts level and volatility of real activity?
- Intuition: Financial markets are forward-looking – potentially capture future economic expectation
- Important for policymakers: Incorporate financial market variables in early warning systems
- Important for investors: Could inform asset prices

Not the first to ask this question:

- Many papers examining link between stock / bond markets and future real activity
- Comprehensive literature review: Stock and Watson (2003):
  - More than 100 papers
  - Over past 15 years
  - More than 43 financial variables
  - Many samples – 17 different countries

Variables tried with varying degree of success:

Table: Ability of variables to predict real activity

Variable	Paper	GDP	$\sigma(GDP)$	IND	$\sigma(IND)$	CON	$\sigma(CON)$	EMP	$\sigma(EMP)$
Term spread	Ang/Piazzesi (2003)								
Stock returns	Schwert; Fama (1990)								
VIX	Bekaert/Hoerova (2014)								
Bond returns	Connolly/Stivers/Sun (2006)								
Commodity	Stock/Watson (2013)								
Forex returns	Stock/Watson (2013)								

Notes: GDP is gross domestic product; IND is industrial production; CON is consumption; EMP is non-farm payroll

This paper: A new variable:

Table: Implied volatility from Treasury markets works well

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YIV	THIS PAPER!								

Notes: GDP is gross domestic product; IND is industrial production; CON is consumption; EMP is non-farm payroll

- Part I: Show YIV predicts level and volatility of real activity
- Part II: Investigate mechanism

YIV is a good candidate variable:

- Intuitive reason: Market for Treasury bonds and notes and related options and futures is largest / most liquid
- Theoretical reason: Models (Bansal / Zhou (2005); Ang / Bekaert (2002); Dai / Singleton (2002); Dai / Singleton / Yang (2007) etc.) suggest interest rate volatility varies over the business cycles
- Surprisingly limited research that uses interest rate uncertainty!

Getting IV for Treasuries:

- Options on T bonds and notes do not exist – Use options on Treasury futures
- Daily data on options on Treasury futures from CME
- Select close to at-the-money call and put options on 5-years futures contract
- Back out implied vol using Black (1976) commodity option pricing model
- Weighted average (by money-ness) of implied volatilities – Call it 5-year YIV
- 5-year YIV captures both interest rate uncertainty and variance risk premia (control for latter)

Summary statistics and correlations:

Table: 1, 2: Summary statistics and correlations.

	Mean	σ	Min	25^{th}	Median	75^{th}	Max	ρ
5-year YIV	3.38	1.17	1.37	2.71	3.12	3.67	9.21	0.71

	GDP	IND	CON	EMP	TRM	ΔSY	ITB	VIX	UNC
5-year YIV	-0.54***	-0.45***	-0.41***	-0.57***	0.18***	-0.12**	0.04	0.49***	0.12**

Notes: Summary statistics for the YIV; GDP is gross domestic product; IND is industrial production; CON is consumption; EMP is non-farm payroll; TRM is term spread; ΔSY is short-rate; ITB is Treasury bond returns; VWR is value-weighted stock returns; VIX is the CBOE Volatility Index; UNC Bloom/Baker/Davis (2015) uncertainty index; Monthly data except for GDP (quarterly); Monthly data, 1990 - 2015.

Empirical framework: Predictive regressions:

$$\sum_{j=1}^{j=H} \log(1 + MACRO_{i,t+j})/H = \alpha_H + \beta_H YIV + Controls + \epsilon_{t+H}$$

- Horizons of 1 - 36 months
- Newey-West / Hansen-Hodrick standard errors (1 - 36) lags
- Control for lags as well as standard predictor variables (term-spread, short rate, VIX, bond returns, stock returns, etc.)

YIV predicts real activity:

Table: 4, A3, A4, A5, A6: Predicting real activity: Coefficient on YIV

$H =$	12	18	24	30	36
GDP	-0.08***	-0.07***	-0.05***	-0.05***	-0.04***
	(-3.61)	(-3.46)	(-3.83)	(-3.99)	(-3.72)
R^2	34.42	26.80	20.72	17.12	14.72
IND	-0.17***	-0.12***	-0.09***	-0.06***	-0.05**
	(-2.90)	(-2.61)	(-2.66)	(-2.48)	(-2.00)
R^2	32.13	20.47	11.75	7.20	4.87
CON	-0.09***	-0.07***	-0.06***	-0.05***	-0.05***
	(-3.31)	(-3.19)	(-3.36)	(-3.52)	(-3.76)
R^2	34.48	27.76	21.63	17.58	16.11
EMP	-0.09***	-0.08***	-0.07***	-0.05***	-0.04***
	(-6.25)	(-5.36)	(-4.97)	(-4.71)	(-4.06)
R^2	44.77	38.55	29.40	21.78	15.52

Notes: Dependent is year-on-year growth rate in the GDP, IND, CON, EMP; Controls include the term spread; changes in short-rate; Treasury bond returns; Corporate bonds returns; Stock index returns; CBOE Volatility Index; Economic uncertainty from Baker/Bloom/Davis (2015); Quarterly or monthly data, 1990 - 2016.

YIV predicts volatility of real activity:

Table: 5, A7, A8, A9, A10: Predicting GDP, IP, CON, EMP volatility: Coefficient on YIV

$H =$	12	18	24	30	36
GDP	0.25***	0.30***	0.30**	0.26**	0.20**
	(2.95)	(2.71)	(2.30)	(2.12)	(2.03)
R^2	25.35	26.99	27.45	29.19	30.60
IND	0.82***	1.06***	1.14***	1.02***	0.82***
	(3.60)	(3.31)	(3.04)	(2.84)	(2.49)
R^2	36.33	34.29	31.41	23.86	16.21
CON	0.28***	0.33***	0.33***	0.30***	0.26***
	(4.06)	(3.37)	(3.08)	(2.90)	(2.53)
R^2	30.69	25.53	20.34	16.58	13.10
EMP	0.22***	0.26***	0.29***	0.29***	0.27***
	(5.04)	(4.19)	(3.74)	(3.52)	(3.13)
R^2	35.48	29.74	24.36	20.34	16.47

Notes: Dependent is year-on-year volatility of IP, CON, EMP; Quarterly or monthly data, 1990 - 2016.

Results robust to a battery of tests:

- Predict over short- and long-term
- Not driven by variance risk premia
- Using non-overlapping data
- Excluding financial crisis
- Out of sample forecasts

Obvious question: Why does this work so well?

YIV captures interest rate volatility (uncertainty) I:

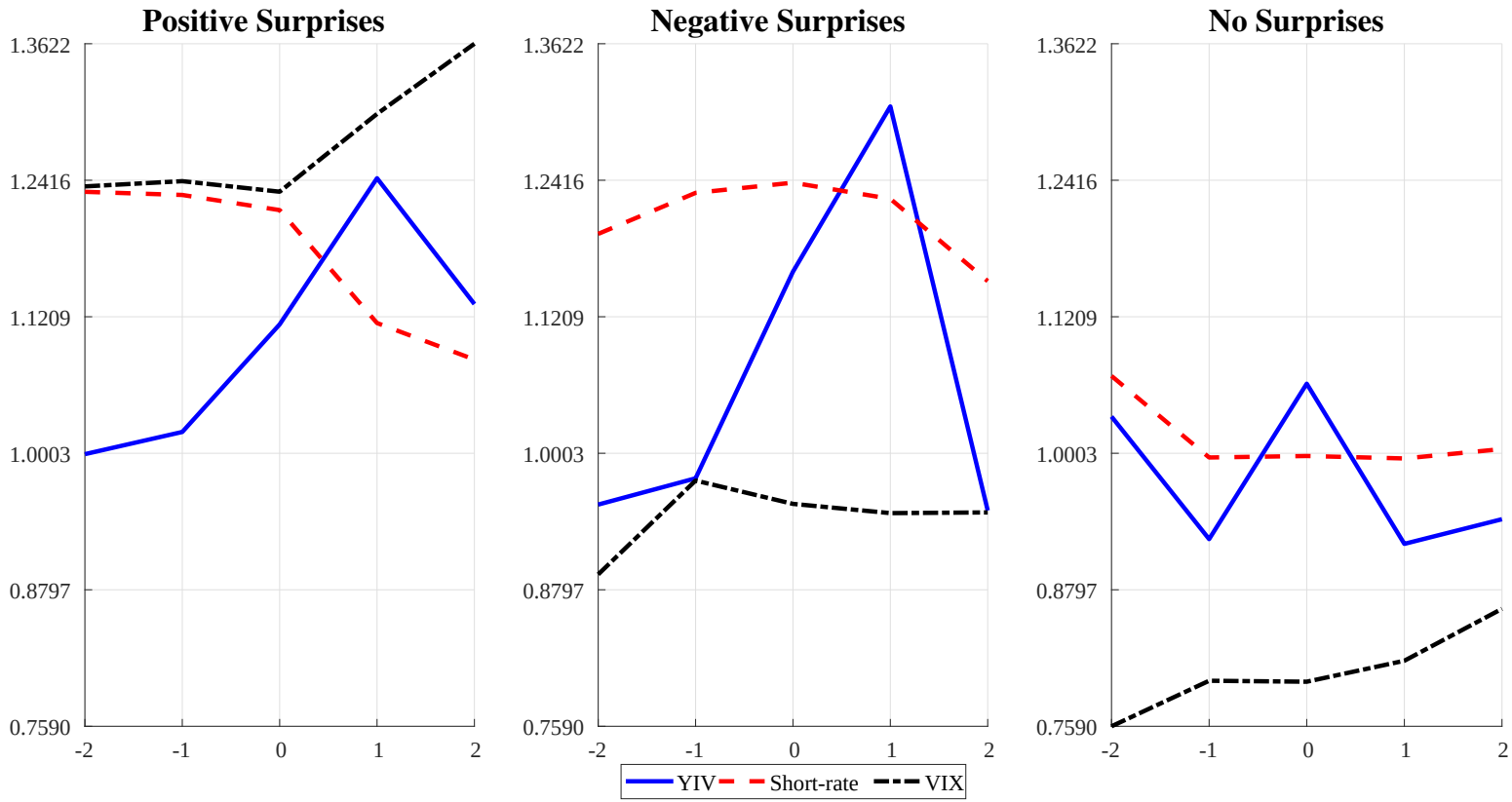
Table: 3: Predicts interest rate volatility

$H =$	12	18	24	30	36
2-year rates	1.45**	1.06*	0.63	0.27	-0.26
	(1.98)	(1.75)	(0.84)	(0.29)	(-0.23)
$R^2 - ord$	6.02	2.33	0.61	0.09	0.07
5-year rates	1.22***	1.11**	1.02**	1.34***	1.66***
	(2.33)	(2.24)	(2.06)	(2.43)	(2.49)
$R^2 - ord$	8.01	6.01	4.71	7.43	10.08
10-year rates	0.63	0.66	0.72	1.17**	1.73***
	(1.57)	(1.38)	(1.48)	(2.23)	(3.20)
$R^2 - ord$	4.28	3.75	3.91	9.12	17.91

Notes: Dependent is realized future volatility of 2-, 5-, 10-year rates.

YIV captures interest rate volatility (uncertainty) II:

Figure: 2: Response of YIV to monetary policy surprises



Notes: YIV, the short rate, and the term spread over a 5-day window around Fed's announcements regarding changes in the Federal Funds rate; Daily data, 1990 - 2016.

- YIV increases on both unexpected rate cuts and increases

Mechanism: YIV impacts real activity via bank balance sheets:

Figure: One possible mechanism

Bank centric view of interest rate risk:

- Banks' core activities deposits-taking and loans exposes their balance sheets to interest rate risk
- Banks cannot completely immunize themselves from interest rate uncertainty / risk
- Interest rate uncertainty impacts bank liabilities $\rightarrow$ assets $\rightarrow$ net worth $\rightarrow$ real activity
- Drechsler/Savov/Schnabl (2017): Monetary policy affects real activity via bank deposits
- Haddad/Sraer (2017): Bank interest rate exposure forecasts bond returns

Support for our mechanism:

- Evidence 1: YIV forecasts lower (higher) demand (volatility) for deposits from banks
- Evidence 2: YIV forecasts cost of capital of banks
- Evidence 3: YIV forecasts level and volatility of bank credit
- Evidence 4: Stronger forecasts for banks more exposed to IR risk
- Evidence 5: YIV forecasts investment for bank dependent firms

Evidence 1: YIV and bank deposits:

Table: 6: Predicting bank deposits

$H =$	12	18	24	30	36
Bank deposit	-0.25***	-0.27***	-0.28***	-0.28***	-0.29***
	(-3.31)	(-4.19)	(-4.70)	(-4.66)	(-4.36)
Bank deposit volatility	0.62***	0.45***	0.25*	0.18	0.12
	(2.64)	(2.68)	(1.64)	(0.98)	(0.62)

Notes: Dependent is bank deposit growth and bank deposit volatility; Monthly data, 1990 - 2016.

Evidence 2: YIV and bank cost of capital:

Table: 7: Predicting bank cost of capital

$H =$	12	18	24	30	36
Libor-OIS spread	0.30**	0.24*	0.15	0.05	-0.07
	(2.00)	(1.82)	(0.99)	(0.28)	(-0.29)
Bank $E[R]$	0.07	0.12	0.21*	0.27**	0.32**
	(1.06)	(1.39)	(1.87)	(2.06)	(2.25)

Notes: Dependent is Libor-OIS spread or dividend yield on bank stocks or dividend yield for stock market; Monthly data, 1990 - 2016.

Evidence 3: YIV and bank credit:

Table: 8: Predicting bank credit

$H =$	12	18	24	30	36
Bank credit	-0.13***	-0.14***	-0.14***	-0.14***	-0.14***
	(-3.07)	(-4.30)	(-4.42)	(-4.51)	(-5.06)
Bank credit volatility	0.61***	0.73***	0.60***	0.46***	0.33***
	(7.02)	(5.47)	(4.75)	(4.51)	(3.52)

Notes: Dependent is bank credit growth and bank credit volatility; Monthly data, 1990 - 2016.

Evidence 4: YIV and bank credit by exposure to IR risk:

Table: 9: Predicting bank credit by exposure to interest rate risk

$H =$	12	18	24	30	36
Small banks, Low Exp.	-0.26***	-0.28***	-0.28***	-0.28***	-0.25***
	(-2.79)	(-3.90)	(-4.40)	(-4.90)	(-4.16)
Small banks, High Exp.	-1.66**	-1.99**	-2.16**	-2.36**	-2.56**
	(-2.01)	(-1.99)	(-2.08)	(-2.20)	(-2.35)
Large banks, Low Exp.	-0.18	-0.07	-0.01	-0.02	0.01
	(-0.59)	(-0.28)	(-0.01)	(-0.09)	(0.03)
Large banks, High Exp.	-0.31***	-0.37***	-0.39***	-0.38***	-0.35**
	(-2.59)	(-2.76)	(-2.60)	(-2.46)	(-2.16)

Notes: IR derivatives held for trading used to compute IR exposure (Purnanandam(2007)); Dependent is bank credit growth; Quarterly data, 1990 - 2016.

Evidence 5: YIV and investment growth:

Table: 10: Predicting firm investment by bank dependence

$H =$	12	18	24	30	36
Bank dependent firms	-0.28*	-0.22	-0.22	-0.34*	-0.31*
	(-1.80)	(-1.44)	(-1.48)	(-1.72)	(-1.47)
Non-bank dependent firms	0.00	0.00	-0.01	-0.03	-0.05
	(0.00)	(0.01)	(-0.14)	(-0.37)	(-0.48)

Notes: Dependent is capex growth; Quarterly data, 1990 - 2016.

- Interest rate uncertainty predicts aggregate capex (Mueller / Vedolin (2017)

Key results:

- I: A simple measure of uncertainty from Treasury derivatives markets predicts level and volatility of macroeconomic activity
- II: Over horizons of 1 - 36 months
- III: Robust to a variety of specifications

Contribution:

- Variable captures interest rate uncertainty
- Directly impacts balance sheet of banks
- Establish a link between time-varying uncertainty in US Treasury markets and balance sheet of banks that impacts real activity