

Exploring the Variance Risk Premium Across Assets

Heston and Todorov 2024 Working Paper

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Introduction

- **Objective:** Examine the variance risk premium (VRP) across equities, bonds, currencies and commodities
- **Method:** novel model-free approach to construct tradable option portfolios that replicate realized variance
- **Main Findings:**
 - ① VRP is negative for most markets
 - ② VRP is more associated with fat tails than with systematic risk
 - ③ Implied variance does not predict underlying returns, but predicts VRP

- 1 Introduction
- 2 Data and Methodology
 - Options data
 - Variance Portfolio Methodology
- 3 Variance Risk Premium Across Assets
 - Returns to Variance
- 4 Comparing Theories of the variance risk premium
 - Systematic Risk
 - Liquidity and Hedging
 - Conditional Returns and Predictive Regressions
- 5 Conclusion and commentaries

Data and Methodology

Data and Methodology: options data

- Options on 20 futures markets
 - ▶ Equities (1): S&P500 Index
 - ▶ Currencies (5): AUD, GBP, CAD, CHF and JPY
 - ▶ Fixed Income (2): US10Y and US30Y Treasury Notes
 - ▶ Commodities (12): Oil, Nat. Gas, Gold, Silver, Copper, Live Cattle, Soy Meal, Soy Oil, Soybeans, Wheat, Coffee and Corn
- Data from IVolatility based on options traded on CME, NYMEX and ICE
- Sample period: Jan 2006 to October 2020
- Filters:
 - ▶ Excludes options with zero bid
 - ▶ Excludes options with zero open interest

Data and Methodology: Variance Portfolio

- Benchmark for option volatility is CBOE VIX formula, but only works well for markets with finely spaced strike prices
- Paper uses Simpson's rule of Heston et al (2022):

$$\begin{aligned} VIX^2 = & \frac{2}{T} e^{rT} \sum_i \frac{\Delta_i}{K_i^2} \min(Put(K_i), Call(K_i)) + \frac{\Delta}{3T} \left(\frac{F - K_0}{K_0^2} + \frac{K_1 - F}{K_1^2} \right) \\ & + \frac{e^{rT}}{3T} \left(\frac{\Delta - \Delta_0}{K_0^2} Put(K_0) + \frac{\Delta - \Delta_1}{K_1^2} Call(K_1) \right) + \frac{1}{T} \left(\log\left(\frac{F^2}{K_0 K_1}\right) - \frac{F}{K_0} - \frac{F}{K_1} + 2 \right), \end{aligned}$$

- This variance index is a portfolio of OTM options, the underlying contract and the risk free asset
- To compute returns, portfolio is constructed and the beginning of each month and held to maturity, with daily delta hedging

Data and Methodology: VIX Summary Statistics

The table shows summary statistics on VIX levels. These are computed as $\sqrt{VIX^2 \times 365/28}$, where VIX^2 is the monthly implied variance. “Mean RVol” is the average realized volatility (also annualized). The sample period is from January 2006 to October 2020.

	Mean	Median	Std (%)	Min	Max	Skew	Kurt	Mean RVol
Australian Dollar	12.4	11.2	5.2	6.4	39.6	2.4	10.9	10.6
British Pound	10.3	9.4	4.0	4.9	29.7	2.3	9.9	8.1
Canadian Dollar	9.7	8.7	3.8	4.6	27.5	1.9	8	7.7
Swiss Franc	10.2	9.8	3.6	3.9	24.2	1.2	5.1	9.4
Japanese Yen	10.9	10.2	3.8	4.9	30.1	1.6	7.8	8.1
S&P 500	22.2	17.6	12.8	9.7	78.0	1.8	6.2	17.3
10 Year UST	6.3	5.8	2.0	3.4	14.7	1.3	5.1	4.2
30 Year UST	11.1	10.5	3.4	6.5	24.0	1.3	4.9	8.2
Brent Crude Oil	38.5	31.0	24.8	17.3	155.0	3.0	13.1	30.1
Natural Gas	50.6	45.7	17.8	21.9	111.7	1.0	3.7	37.7
Gold	19.0	18.0	6.5	9.5	51.2	1.6	7.3	14.5
Silver	33.7	32.7	12.4	15.6	78.6	1.2	4.7	26.4
Copper	29.4	26.9	11.3	13.5	76.6	1.6	6.3	21.2
Live Cattle	19.1	18.2	7.2	8.1	68.3	3.0	19.6	13.7
Soybean Meal	29.3	28.4	8.2	14.4	53.5	0.7	3.4	20.9
Soybean Oil	24.7	23.3	6.8	15.2	70.5	2.7	16.8	18.1
Soybeans	25.2	24.1	8.1	12.1	56.1	1.4	5.0	18.6
Wheat	33.5	30.4	10.8	19.1	71.9	1.2	4.2	25.1
Coffee C	35.6	34.2	7.4	22.0	56.5	0.4	2.6	25.1
Corn	32.4	31.3	9.3	17.2	64.9	0.7	3.3	22.9

Variance Risk Premium Across Assets

Returns to Variance

- Swiss Franc the only asset with positive average return
- CAD and JPY the only currencies with with significant sharpe ratio
- 10Y Treasury with the lowest return and sharpe

	Hedged VIX^2 returns and option measures				
	Mean (%)	Std (%)	Sharpe	Skew	Kurt
Australian Dollar	-2.1	57.4	-0.14	4.0	27.4
British Pound	-9.4	75.2	-0.46	8.44	94.31
Canadian Dollar	-8.8	61.2	-0.52*	4.6	35.0
Swiss Franc	14.8	274.3	0.19	11.2	130.5
Japanese Yen	-16.6	61.4	-0.98***	2.7	13.1
S&P 500	-11.9	192.0	-0.23	8.6	90.7
S&P 500 pre-Covid	-22.9	100.0	-0.86***	4.56	26.01
10 Year UST	-25.8	31.5	-2.97***	1.4	6.2
30 Year UST	-14.4	37.4	-1.41***	1.6	5.9
Brent Crude Oil	-12.2	96.2	-0.46	5.4	39.7
Natural Gas	-14.1	62.2	-0.80***	6.4	61.3
Gold	-11.7	101.0	-0.42	8.4	88.5
Silver	-5.5	144.1	-0.11	3.5	48.0
Copper	-17.6	45.5	-1.41***	1.8	6.8
Live Cattle	-22.0	52.5	-1.52***	2.8	14.0
Soybean Meal	-15.7	40.9	-1.40***	1.5	5.8
Soybean Oil	-16.7	43.3	-1.40***	1.6	7.1
Soybeans	-21.4	42.4	-1.95***	1.5	6.0
Wheat	-13.4	39.6	-1.30***	1.1	4.6
Coffee C	-18.5	42.7	-1.57***	1.7	7.9
Corn	-22.9	50.3	-1.71***	1.0	6.6

Correlation of Variance Returns Across Assets

Panel B: Hedged VIX^2 returns correlations

	Australian Dollar	British Pound	Canadian Dollar	Swiss Franc	Japanese Yen	S&P 500	10 Year UST	30 Year UST	Brent Oil	Natural Gas	Gold	Silver	Copper	Live Cattle	Soybean Meal	Soybean Oil	Soybeans	Wheat	Coffee C	Corn
British Pound	0.64																			
Canadian Dollar	0.77	0.68																		
Swiss Franc	0.13	0.44	0.27																	
Japanese Yen	0.32	0.17	0.29	0.03																
S&P 500	0.15	0.10	0.10	0.03	0.47															
10 Year UST	0.08	-0.03	0.07	0.00	0.23	0.11														
30 Year UST	0.08	-0.06	0.06	-0.04	0.28	0.33	0.81													
Brent Crude Oil	0.06	0.14	0.01	0.23	0.52	0.75	0.19	0.18												
Natural Gas	0.01	0.09	0.00	-0.05	0.10	0.08	-0.07	-0.09	0.25											
Gold	-0.01	0.06	0.02	0.00	0.20	0.26	0.02	0.17	0.11	0.03										
Silver	0.00	0.06	-0.05	0.04	0.34	0.66	0.08	0.12	0.66	0.11	0.53									
Copper	0.11	-0.06	0.06	-0.06	0.26	0.33	0.06	0.18	0.27	0.04	0.27	0.37								
Live Cattle	0.35	0.41	0.35	0.02	0.27	0.22	-0.15	-0.07	0.47	0.16	0.05	0.24	0.10							
Soybean Meal	-0.11	-0.06	-0.04	0.00	0.05	-0.01	-0.04	-0.05	-0.05	0.02	0.01	0.09	0.13	0.04						
Soybean Oil	0.01	0.00	-0.07	0.08	0.09	0.13	0.16	0.23	0.11	-0.04	0.24	0.11	0.10	-0.02	0.33					
Soybeans	0.06	-0.04	0.06	-0.02	0.13	0.19	0.01	0.06	0.07	-0.02	0.04	0.12	0.21	0.13	0.57	0.25				
Wheat	-0.06	-0.02	0.00	0.06	0.08	0.08	0.05	0.08	0.10	-0.09	0.13	0.16	0.19	-0.02	0.19	0.10	0.33			
Coffee C	0.18	0.14	0.16	-0.01	0.14	0.03	0.15	0.15	0.26	0.19	0.08	0.13	-0.09	0.27	0.11	0.14	0.21	0.20		
Corn	-0.07	-0.09	-0.10	-0.01	-0.01	-0.22	0.25	0.12	0.11	-0.12	0.15	0.22	0.23	-0.09	0.28	0.04	0.33	0.47	0.04	
Eq. Weighted	0.32	0.32	0.34	0.37	0.55	0.81	0.25	0.31	0.84	0.17	0.45	0.75	0.39	0.39	0.2	0.31	0.32	0.28	0.28	0.21

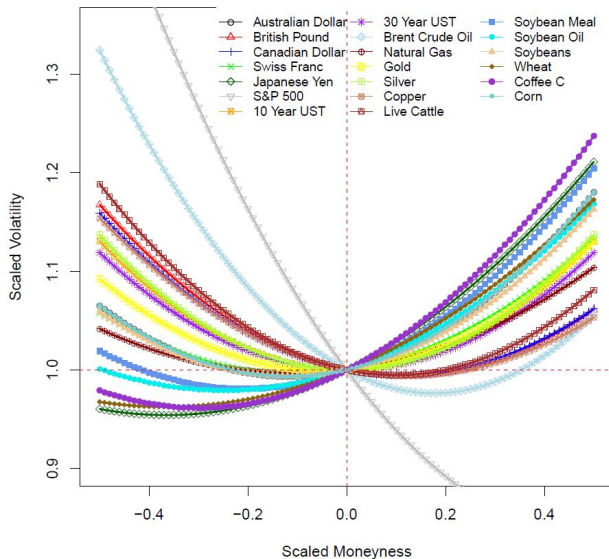
- Oil, S&P500 and Silver shows highest correlation to equally weighted average: proxies for systematic risk
- Commodities show the least correlation to equally weighted average

Correlation of underlying returns with variance returns

Panel C: Futures-Hedged VIX^2 returns cross-correlations

	Australian Dollar, F	British Pound, F	Canadian Dollar, F	Swiss Franc, F	Japanese Yen, F	S&P 500, F	10 Year UST, F	30 Year UST, F	Brent Oil, F	Natural Gas, F	Gold, F	Silver, F	Copper, F	Live Cattle, F	Soybean Meal, F	Soybean Oil, F	Soybeans, F	Wheat, F	Coffee C, F	Corn, F	Eq. Weighted, F
Australian Dollar, V	-0.36	-0.11	-0.25	-0.04	0.17	0.03	0.11	0.03	-0.25	0.03	0.16	0.03	0.03	-0.21	-0.07	-0.03	-0.13	0.06	0.09	-0.03	-0.06
British Pound, V	-0.25	-0.22	-0.21	-0.12	0.04	0.26	0.03	0.04	-0.3	0.04	0.11	-0.02	0.06	-0.26	-0.12	-0.11	-0.12	-0.06	0.01	-0.12	-0.15
Canadian Dollar, V	-0.29	-0.17	-0.20	-0.09	0.07	0.09	0.23	0.15	-0.18	-0.03	0.12	-0.03	0.01	-0.30	-0.10	-0.11	-0.11	-0.10	0.03	-0.14	-0.16
Swiss Franc, V	-0.11	0.13	-0.17	0.30	0.10	0.03	-0.16	-0.18	-0.28	0.00	-0.16	-0.12	0.10	-0.10	0.05	0.00	0.04	-0.02	-0.13	0.01	-0.05
Japanese Yen, V	-0.17	-0.06	-0.11	0.13	0.27	-0.35	0.26	0.25	-0.37	0.02	0.08	-0.08	-0.16	-0.21	0.09	0.09	0.05	0.14	-0.06	0.12	-0.10
S&P 500, V	-0.06	-0.01	-0.09	0.12	0.21	-0.63	0.30	0.20	-0.49	-0.07	0.11	-0.19	-0.22	-0.22	0.08	-0.06	-0.15	0.04	-0.08	-0.07	-0.36
10 Year UST, V	-0.19	-0.05	-0.01	0.09	0.11	-0.20	0.01	0.04	-0.13	-0.01	0.09	-0.03	0.09	-0.08	-0.15	-0.07	-0.08	-0.05	0.08	-0.09	-0.07
30 Year UST, V	-0.15	-0.03	-0.07	0.03	0.18	-0.38	0.13	0.16	-0.17	-0.09	0.08	-0.03	-0.10	-0.06	-0.14	-0.12	-0.14	-0.03	0.03	-0.10	-0.17
Brent Crude Oil, V	-0.12	-0.12	-0.14	0.16	0.23	-0.46	0.15	0.16	-0.59	0.07	-0.04	-0.21	-0.29	-0.36	-0.01	-0.01	-0.09	0.09	0.06	0.04	-0.35
Natural Gas, V	0.04	-0.07	-0.04	-0.03	0.01	-0.04	-0.04	-0.02	-0.23	0.20	0.04	0.01	-0.01	-0.19	-0.01	-0.03	-0.04	-0.02	0.03	-0.01	-0.01
Gold, V	-0.08	0.01	0.02	0.01	0.00	-0.21	0.11	0.15	-0.13	0.01	-0.08	-0.18	-0.14	-0.08	0.00	-0.12	-0.06	0.01	-0.08	-0.11	-0.13
Silver, V	-0.12	0.01	-0.06	0.09	0.09	-0.35	0.05	0.07	-0.42	-0.01	-0.22	-0.25	-0.17	-0.26	-0.09	-0.16	-0.16	-0.13	-0.08	-0.10	-0.35
Copper, V	-0.13	-0.08	-0.14	-0.17	0.11	-0.22	0.18	0.19	-0.23	0.12	-0.09	-0.06	-0.28	0.00	-0.07	0.02	-0.01	0.15	-0.06	0.08	-0.09
Live Cattle, V	-0.20	-0.11	-0.14	-0.06	0.08	0.04	-0.08	-0.03	-0.25	0.10	0.08	0.06	-0.11	-0.38	-0.18	-0.01	-0.23	-0.15	0.13	-0.16	-0.2
Soybean Meal, V	0.06	-0.10	-0.05	-0.07	-0.15	-0.03	-0.03	0.01	0.00	0.15	-0.01	0.15	-0.14	0.06	0.36	-0.11	0.09	0.10	0.07	0.07	0.09
Soybean Oil, V	-0.04	-0.05	-0.12	-0.03	0.02	-0.16	-0.03	0.04	-0.24	0.08	-0.01	0.05	-0.08	0.08	-0.06	-0.04	-0.13	-0.12	-0.02	-0.02	-0.08
Soybeans, V	-0.02	-0.15	-0.14	-0.11	-0.04	-0.27	0.26	0.22	0.13	0.06	0.12	0.16	-0.15	-0.02	-0.03	-0.17	-0.19	0.06	0.03	0.02	-0.01
Wheat, V	-0.02	0.02	-0.05	0.03	0.03	-0.12	0.08	0.09	-0.16	0.02	-0.08	-0.03	-0.12	0.09	0.12	-0.07	0.00	0.23	0.08	0.07	0.05
Coffee C, V	-0.07	-0.07	0.00	0.04	-0.03	-0.11	-0.07	-0.04	-0.19	0.16	0.13	0.04	-0.03	-0.20	0.13	0.00	0.12	0.07	0.38	0.11	0.12
Corn, V	-0.02	-0.07	-0.03	0.02	-0.03	0.08	0.12	0.17	-0.16	0.20	-0.18	0.02	-0.02	0.06	-0.04	-0.22	0.06	0.21	0.21	0.19	0.2
Eq. Weighted, V	-0.21	-0.08	-0.20	0.15	0.20	-0.43	0.13	0.12	-0.60	0.05	-0.07	-0.20	-0.19	-0.32	-0.03	-0.13	-0.12	0.00	-0.02	-0.02	-0.29

Implied volatility smiles



Comparing Theories of the variance risk premium

Comparing Theories of the variance risk premium

Three possible theoretical explanations of the variance risk premium:

① Systematic Risk

- ▶ risk premiums are associated with intertemporal hedging demand for risks that affect investment opportunities
- ▶ level of marketwide variance is a natural proxy

② Hedging and Liquidity Risk:

- ▶ due to price jumps and fat tails, options are costly and difficult to hedge. Dealer must charge a premium to cover this costs
- ▶ illiquidity and jumps should be associated with larger negative VRP

③ Conditional Risk

- ▶ level of implied volatility reflects a changing conditional risk premium

Two regression:

- ① Underlying risk explaining VRP:
 - ▶ VRP as a function of returns of the Underlying
 - ▶ α only insignificant for 6 assets
- ② Systematic risk explaining VRP:
 - ▶ VRP as a function of returns of the cross sectional average VIX^2 returns
 - ▶ α only insignificant for 4 assets

Systematic Risk: Results

	$r_t^{VIX} = \alpha + \beta r_t^F + \epsilon_t$					$r_t^{VIX} = \alpha_{EW} + \beta_{EW} r_t^{VIX_{EW}} + \epsilon_t$				
	α (1)	α se (2)	β (3)	β se (4)	IR (5)	α_{EW} (6)	α_{EW} se (7)	β_{EW} (8)	β_{EW} se (9)	IR _{EW} (10)
Australian Dollar	-0.01	0.04	-6.25	1.26	-0.07	0.03	0.04	0.41	0.09	0.20
British Pound	-0.10	0.06	-6.49	2.21	-0.49*	-0.02	0.06	0.56	0.13	-0.10
Canadian Dollar	-0.09	0.05	-5.25	2.13	-0.54*	-0.04	0.05	0.45	0.10	-0.25
Swiss Franc	0.17	0.22	28.00	7.58	0.23	0.37	0.22	2.11	0.45	0.52*
Japanese Yen	-0.16	0.05	6.49	1.79	-0.97***	-0.07	0.04	0.77	0.09	-0.49*
S&P 500	0.07	0.12	-22.67	2.18	0.17	0.31	0.09	3.47	0.19	1.00***
10 Year UST	-0.26	0.03	0.22	2.11	-2.97***	-0.22	0.03	0.27	0.10	-2.59***
30 Year UST	-0.15	0.03	2.21	1.20	-1.46***	-0.10	0.03	0.36	0.10	-1.01***
Brent Crude Oil	-0.10	0.08	-5.14	0.74	-0.46	0.10	0.06	1.54	0.10	0.68*
Natural Gas	-0.11	0.05	1.09	0.42	-0.65**	-0.11	0.05	0.23	0.11	-0.65**
Gold	-0.10	0.08	-1.82	1.77	-0.36	0.10	0.08	1.53	0.24	0.40
Silver	-0.01	0.11	-4.13	1.31	-0.03	0.20	0.08	2.30	0.17	0.75***
Copper	-0.17	0.04	-1.97	0.54	-1.40***	-0.13	0.03	0.39	0.07	-1.12***
Live Cattle	-0.23	0.04	-4.22	0.92	-1.71***	-0.18	0.04	0.42	0.09	-1.34***
Soybean Meal	-0.16	0.03	0.87	0.46	-1.42***	-0.12	0.04	0.27	0.11	-1.08***
Soybean Oil	-0.17	0.04	-0.30	0.66	-1.41***	-0.09	0.04	0.47	0.12	-0.79***
Soybeans	-0.21	0.03	-1.22	0.53	-1.82***	-0.15	0.04	0.45	0.11	-1.34***
Wheat	-0.11	0.03	1.11	0.41	-1.03***	-0.08	0.04	0.36	0.11	-0.76**
Coffee C	-0.17	0.04	1.99	0.46	-1.55***	-0.14	0.04	0.37	0.12	-1.23***

Liquidity and Hedging

- Expect to see more negative VRP in markets with illiquidity of fat-tailed jumps in prices
- Two measures of illiquidity:
 - ① log of volume ratio of futures to options contracts
 - ② average deviation of options quotes from put-call parity
- Jumps and fatness measured by skewness and kurtosis of the underlying return in the previous month

Liquidity and Hedging: Fama-MacBeth Regression

<i>Dependent variable: hedged VIX² return</i>							
Volume ratio	-0.04** (0.02)						-0.02 (0.02)
Put-call deviations		4.68 (25.78)					21.18 (32.52)
Skewness			-0.02 (0.03)				-0.003 (0.03)
Kurtosis				0.07*** (0.02)			0.07*** (0.02)
VIX level					-0.01*** (0.002)		-0.01*** (0.004)
VIX standard deviation						0.01 (0.02)	0.02** (0.01)
Intercept	-0.10 (0.08)	-0.15*** (0.03)	-0.15*** (0.02)	-0.37*** (0.06)	0.01 (0.03)	-0.14*** (0.02)	-0.13* (0.08)
Observations	2,804	2,804	2,804	2,804	2,804	2,804	2,804

Conditional Returns and Predictive Regressions

Two predictive regressions:

- 1 Underlying returns explained by ex-ante VRP:

$$r_{t \rightarrow T}^F = \alpha + \beta(VIX_t^2 - RV_{t-1,t}) + \epsilon_t$$

- ▶ Most β s insignificant
- ▶ Some are significant but negative

- 2 VIX^2 returns explained by ex-ante VRP:

$$r_{t \rightarrow t+1}^{hedged\ VIX} \times VIX_t^2 = \alpha + \beta(VIX_t^2 - RV_{t-1,t}) + \epsilon_t$$

- ▶ Except for currencies, most assets have $\beta < 0$
- ▶ ex-ante VRP predicts variance returns

Conditional Returns and Predictive Regressions

Table 7

Bollerslev-Tauchen-Zhou predictive regressions

Panel A shows β from the regression $r_{t-T}^F = \alpha + \beta(VIX_t^2 - RV_{t-1,t}) + \epsilon_t$. Panel B shows β from the regression $r_{t-T}^{hedged VIX} = \alpha + \beta(VIX_t^2 - RV_{t-1,t}) + \epsilon_t$. RV is realized variance measured by the sum of daily squared returns over a given month. $r_{t-T}^{hedged VIX}$ is the return on the hedged VIX^2 portfolio over horizon T months. r_{t-T}^F is the return on the futures over horizon T months. t -statistics accounting for the overlap following [Hodrick \(1992\)](#) are reported in parentheses below each estimate in brackets.

	Tot + 1m (1)	Tot + 3m (2)	Panel A: r_{t-T}^F Tot + 6m (3)	Tot + 12m (4)	Panel B: $r_{t-T}^{hedged VIX}$ Tot + 6m (5)
Australian Dollar	-5.44 (-0.92)	-3.41 (-1.03)	-4.98 (-1.95)	-2.07 (-1.03)	0.39 (2.71)
British Pound	-7.30 (-3.39)	-1.11 (-0.88)	-1.32 (-1.42)	-0.13 (-0.26)	0.11 (1.50)
Canadian Dollar	-6.53 (-1.73)	-0.32 (-0.13)	2.64 (0.92)	2.92 (2.48)	0.16 (1.50)
Swiss Franc	0.24 (3.18)	0.11 (0.67)	0.46 (3.86)	0.30 (3.55)	0.08 (2.35)
Japanese Yen	1.62 (0.97)	-0.28 (-0.13)	-1.60 (-1.02)	-0.37 (-0.37)	-0.30 (-1.77)
StoP 500	0.12 (0.35)	0.48 (2.57)	-0.07 (-0.32)	-0.08 (-0.68)	-0.63 (-2.51)
10 Year UST	26.79 (3.91)	5.25 (1.23)	2.51 (0.64)	5.68 (1.94)	-0.56 (-13.41)
30 Year UST	-4.89 (-0.79)	-7.40 (-2.24)	-7.14 (-1.89)	-1.18 (-0.48)	-0.33 (-2.34)
Brent Crude Oil	1.03 (1.32)	1.02 (6.29)	1.29 (1.98)	0.16 (0.42)	1.02 (-10.53)
Natural Gas	0.07 (0.67)	0.19 (3.39)	0.08 (4.36)	0.05 (2.54)	-0.36 (-22.07)
Gold	0.72 (0.27)	0.79 (0.67)	0.22 (0.25)	0.18 (0.27)	-0.04 (-1.99)
Silver	0.69 (0.69)	1.07 (1.68)	-0.10 (-0.19)	-0.34 (-1.01)	0.04 (0.13)
Copper	2.12 (1.75)	1.63 (1.74)	1.37 (2.22)	1.07 (3.11)	-0.17 (-0.53)
Live Cattle	-0.33 (-0.12)	-0.39 (-0.2)	1.02 (0.81)	-0.17 (-0.08)	-1.04 (-2.80)
Soybean Meal	0.00 (0.00)	0.95 (0.93)	0.22 (0.34)	0.05 (0.12)	-0.15 (-1.09)
Soybean Oil	1.26 (1.38)	-0.16 (-0.44)	0.21 (0.77)	0.37 (1.16)	-0.51 (-4.72)
Soybeans	0.12 (2.45)	2.89 (5.91)	0.40 (0.56)	0.14 (0.21)	-0.45 (-5.79)
Wheat	1.06 (3.30)	-1.80 (-1.69)	-1.24 (-1.26)	-0.96 (-1.44)	-0.39 (-2.85)
Coffee C	0.94 (0.40)	0.15 (0.18)	0.32 (0.65)	-0.11 (-0.26)	-0.13 (-0.74)
Corn	1.99 (0.92)	0.74 (0.96)	-0.55 (-0.70)	-0.42 (-0.58)	-0.37 (-1.94)

returns, most of the assets have significant estimates at the 5% level.¹⁴ **Except for currencies, the majority of assets have positive regression slope estimates, meaning that larger realized implied variance (in excess of historical variance) is associated with larger future variance returns. In other words, the time series of implied variance positively forecasts the future variance premium.** These

Conclusion and commentaries

Conclusion and commentaries

- Negative VRP is pervasive across asset classes
- Vol smile slope is heterogeneous
- VRP not highly correlated across asset classes
- VRP not explained by systemic or underlying risk
- VRP related to fat-tails
- VRP is predictable
- Commentaries:
 - ▶ sensitive to sample period?
 - ▶ why FX is an outlier?
 - ▶ surprising divergence between 10Y e 30Y Treasuries results

The End

thanks!