Probability Weighing and Commodity Futures Returns

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Summary

■ **Central Research Question:**

- Does probability weighting affect the cross-section of commodity futures returns?

■ **Motivations**:

- Understanding how speculative trading affects commodity futures prices is a long-lasting question in the area of commodity futures research.
- Existing studies mainly rely on trader position information from Commodity Futures Trading Commission (CFTC) to investigate speculative trading in commodity markets.
- However, empirical evidence regarding whether specific investor behavioral bias, which underpins speculative trading, may affect commodity returns remains lacking in the literature.

■ **Main Empirical Findings**

- High probability weighting value commodities significantly *underperform* low probability weighting value commodities.
- The predictive power cannot be explained by risk factors or other commodity characteristics.
- Beta sorting and alternative risk factors do not support a risk-based explanation.
- Limits to arbitrage contributes to the predictability.
- Comprehensive robustness checks support our main findings.

■ **Contributions**

- We introduce a new commodity return predictor motivated by a behavioral theory.
- We provide new empirical evidence in commodity futures markets.
- We first formally study on probability weighting on commodity market and show that results are robust after controlling for skewness.

Data and Variables

■ **Data:**

- Commodity Futures Data: daily settlement price, trading volume, and open interest on 26 active traded US commodity futures contracts from Bloomberg from February 1982 to October 2019
- 13 agricultural futures, 4 livestock futures, 5 metal futures, 4 energy futures
- Log return of futures prices, assuming a fully-collateralized position in futures markets

■ **Variables**

- A vector of historical commodity return with equal probability, sort from negative to positive

$$\left(r_{-m},\frac{1}{K};r_{-m+1},\frac{1}{K};\dots;r_{-1},\frac{1}{K};r_1,\frac{1}{K};\dots r_{n-1},\frac{1}{K};r_n,\frac{1}{K}\right)$$

- (Cumulative) prospect theory value by Tverkey and Kahneman (1992)

$$TK\equiv\sum_{j=-m}^{-1}v(r_j)\left[w^-\left(\frac{j+m+1}{K}\right)-w^-\left(\frac{j+m}{K}\right)\right]+\sum_{j=1}^{n}v(r_j)\left[w^+\left(\frac{n-j+1}{K}\right)-w^+\left(\frac{n-j}{K}\right)\right]$$

- Probability weighting function and Value function

$$\pi_i=\begin{cases}w^+(p_i+\cdots+p_n)-w^+(p_{i+1}+\cdots+p_n),0\le i\le n\\ w^-(p_{-m}+\cdots+p_i)-w^-(p_{-m}+\cdots+p_{i-1}),-m\le i\le 0\end{cases}\qquad v(r)=\begin{cases}r^\alpha & r\ge 0\\ -\lambda(-r)^\alpha & r<0\end{cases}$$

$$w^+(P)=\frac{P^\gamma}{(P^\gamma+(1-P)^\gamma)^{1/\gamma}},\ w^-(P)=\frac{P^\delta}{(P^\delta+(1-P)^\delta)^{1/\delta}}$$

- Parameters (α, λ, γ, δ) are (1, 1, 0.61, 0.69) for the probability weighting component (PW), follow the literature
- Use the past five year rolling window of monthly commodity return to obtain a monthly commodity-level probability weighting value (pw)

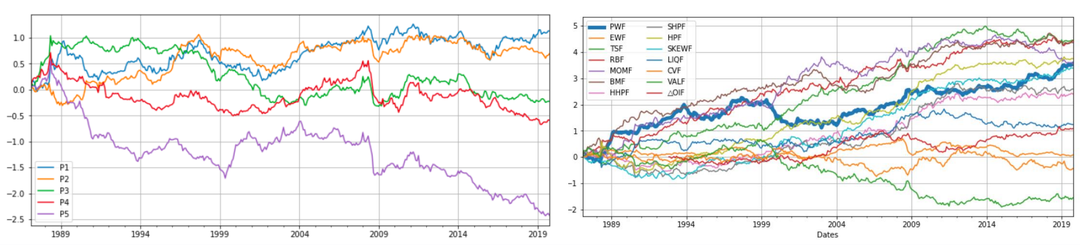
Empirical Results

■ **Univariate Portfolio Sorting**

Panel A: Portfolio Performance

	P1	P2	P3	P4	P5	P1-P5
Avg Return	0.03	0.02	-0.01	-0.02	-0.07*	0.11**
	(0.98)	(0.66)	(-0.19)	(-0.53)	(-1.87)	(2.33)
Std	0.20	0.16	0.18	0.18	0.20	0.23
Sharpe Ratio	0.18	0.13	-0.04	-0.10	-0.37	0.47
Skewness	0.64	0.01	1.05	-0.52	-0.61	0.46
Excess Kurtosis	4.51	1.53	8.95	3.63	3.59	1.50
Maximum Drawdown	-0.54	-0.52	-0.74	-0.75	-0.95	-0.68

■ **Cumulative Returns of Commodity Portfolios Sorted by Probability Weighting Values and Different Commodity Factor Portfolios**



■ **Alphas and Factor Loadings**

Panel B: Alphas and Factor Loadings

Model	(1)	(2)	(3)	(4)
α	0.16***	0.16***	0.15***	0.12***
	(3.82)	(3.80)	(3.88)	(3.13)
EWF	-0.13	-0.13	-0.10	-0.10
	(-1.42)	(-1.40)	(-1.09)	(-1.53)
TSF	-0.08	-0.08	-0.14**	-0.11
	(-1.02)	(-1.15)	(-2.10)	(-1.54)
MOMF	-0.34***	-0.33***	-0.35***	-0.29***
	(-4.30)	(-4.11)	(-4.57)	(-3.74)
HPF		-0.05	-0.02	0.08
		(-0.77)	(-0.31)	(0.86)
RBF			-0.01	-0.09
			(-0.13)	(-1.62)
BMF			0.14**	0.11
			(2.02)	(1.19)
SKEWF				0.00
				(0.02)
△OIF				-0.10
				(-1.30)
LIQF				0.02
				(0.27)
VALF				0.30***
				(3.30)
CVF				0.00
				(-0.04)
Adjusted R-squared	0.16	0.16	0.16	0.23

■ **Multivariate Regression Analysis**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
pw	-0.053***	-0.056***	-0.063***	-0.054***	-0.056***	-0.056***	-0.055***	-0.055***	-0.056***	-0.044***	-0.054***	-0.054***	-0.048***
	(-4.33)	(-4.65)	(-5.25)	(-4.39)	(-4.36)	(-3.63)	(-4.40)	(-4.47)	(-4.46)	(-3.28)	(-4.27)	(-4.44)	(-3.28)
ts		0.031*											0.025
		(1.86)											(1.32)
mom			0.029*										0.017
			(1.97)										(0.68)
hhp				0.029*									0.003
				(1.85)									(0.13)
shp					0.029*								0.020
					(1.80)								(0.83)
val						-0.001							0.020
						(-0.05)							(0.85)
cv							-0.006						-0.006
							(-1.30)						(-1.38)
skew								-0.049**					-0.058***
								(-2.76)					(-3.11)
liq									-0.021***				-0.020***
									(-7.00)				(-6.84)
△oi										0.006			0.003
										(0.82)			(0.51)
bm											0.008		0.001
											(0.27)		(0.02)
rb												0.024*	0.009
												(1.77)	(0.74)
Observations	7,886	7,886	7,886	7,866	7,866	7,538	7,547	7,547	7,543	7,341	7,886	7,886	6,992
R-squared	0.201	0.202	0.202	0.203	0.203	0.205	0.200	0.201	0.201	0.188	0.201	0.202	0.190
Commodity FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Commodity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Understanding the Predictability

■ **Risk-Based Explanations**

- Beta Sorted Portfolios

	P1	P2	P3	P4	P5	P1-P5
Avg Return	-0.0126	-0.0064	-0.0086	-0.0305	-0.0425	0.0299
	(-0.37)	(-0.20)	(-0.25)	(-0.88)	(-1.16)	(0.67)
Std	0.17	0.17	0.18	0.17	0.19	0.20
Sharpe Ratio	-0.07	-0.04	-0.05	-0.18	-0.22	0.15
Skewness	-0.48	0.22	-0.67	-0.38	-0.22	-0.19
Excess Kurtosis	2.35	2.66	2.41	0.64	1.93	0.55
Maximum Drawdown	-0.65	-0.54	-0.51	-0.75	-0.77	-0.67
Avg *pw*	0.0028	0.0025	0.0024	0.0013	0.0013	0.0015
Avg β_{PWF}	-10.42	-5.31	-2.74	-0.91	1.78	-12.21

- Alternative Risk Factors

	b1	*b2*	*λ1*	*λ2*	*R-Squared*	*RMSE*	χ^2
$EWF+\triangle VOL_M$	-28.13*	0.06	-0.03	5.30	0.74	0.16	0.63
	(-1.67)	(0.39)	(-1.59)	(0.37)			[0.89]
$EWF+\triangle LIQ_M$	-20.29	0.05	-0.02	2.63	0.82	0.13	0.73
	(-1.11)	(0.51)	(-1.22)	(0.57)			[0.87]
EWF+LEVF	-21.31	0.01	-0.03	1.04	0.76	0.15	0.88
	(-0.72)	(0.20)	(-0.69)	(0.12)			[0.83]
EWF+CAPRF	-25.89	-2.16	-0.03*	-0.02	0.74	0.16	0.71
	(-1.63)	(-0.31)	(-1.77)	(-0.62)			[0.87]
$MKT+MKT^-$	-0.14	0.10	-1.26	-0.55	0.02	0.31	5.38
	(-0.68)	(0.21)	(-0.42)	(-0.21)			[0.15]

■ **Mispricing-Based Explanations**

- Limits to Arbitrage

	Commodity-Specific Measures			Aggregate Market Measures		
	(1)	(2)	(3)	(4)	(5)	(6)
	illiq	*ivol*	*oi*	*ΔVIX*	*ΔFSI*	*TED*
pw	-0.05**	0.06*	-0.07***	-0.05***	-0.04**	-0.05*
	(-2.75)	(1.82)	(-5.10)	(-3.86)	(-2.35)	(-1.65)
lim	-0.01	-0.02	-0.02	-0.01	-0.03**	-0.02
	(-0.67)	(-0.49)	(-1.61)	(-0.83)	(-2.23)	(-0.81)
pw x lim	-0.02	-0.12***	0.02*	-0.02*	-0.03***	-0.01
	(-0.82)	(-3.10)	(1.73)	(-2.04)	(-3.95)	(-0.35)
ts	-0.04**	-0.04**	-0.34***	-0.34***	-0.34***	-0.34
	(-2.12)	(-2.31)	(-20.87)	(-19.42)	(-18.39)	(-19.23)
mom	0.03	0.05*	0.04*	0.01	0.01	0.01
	(1.16)	(1.99)	(1.94)	(0.89)	(0.64)	(0.80)
hhp	-0.01	0.00	0.01	0.00	0.00	0.01
	(-0.33)	(0.08)	(0.30)	(0.16)	(-0.11)	(0.28)
shp	0.03	0.01	0.01	0.02	0.03	0.01
	(1.44)	(0.57)	(0.61)	(0.81)	(1.05)	(0.57)
val	0.01	0.01	0.02	0.01	0.02	0.01
	(0.49)	(0.34)	(0.82)	(0.53)	(0.76)	(0.55)
cv	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	(-1.66)	(-0.98)	(-1.43)	(-1.13)	(-1.16)	(-1.04)
skew	-0.06***	-0.06***	-0.05	-0.07***	-0.07***	-0.06***
	(-2.83)	(-3.20)	(-2.88)	(-3.62)	(-3.52)	(-3.7)
liq		-0.02***	-0.02***	-0.02***	-0.01***	-0.02***
		(-7.37)	(-6.08)	(-10.7)	(-9.46)	(-10.09)
oi	0.01	0.00		-0.01	-0.01	-0.01
	(1.56)	(0.20)		(-0.38)	(-0.49)	(-0.46)
bm	0.01	0.00	0.01	0.01	0.01	0.01
	(0.42)	(-0.03)	(0.26)	(0.36)	(0.31)	(0.42)
rb	0.04	0.06***	0.03	0.01	0.02	0.01
	(1.61)	(3.37)	(1.07)	(0.44)	(0.49)	(0.48)
Observations	6,411	6,992	6,892	6,669	6,262	6,892
R-squared	0.1936	0.1935	0.2600	0.0986	0.1006	0.0971
Commodity FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Commodity	Yes	Yes	Yes	Yes	Yes	Yes

- Heterogenous Trading by Commercial and Non-Commercial Traders

	P1	P2	P3	P4	P5	P5-P1
PT for Commercials	0.71	0.76	0.81	0.86	0.83	0.12
						(1.47)
PT for Non-Commercials	1.48	1.57	1.59	1.81	1.80	0.33***
						(5.64)
Q for Commercials	0.06	0.06	0.04	0.02	0.05	-0.01
						(-0.14)
Q for Non-Commercials	-0.04	-0.04	-0.03	0.00	0.02	0.06***
						(2.81)

Robustness

- Results are robust to alternative estimation windows to obtain commodity probability weighting values.
- Using different conjunction methods do not affect our findings.
- Results hold in general in two sub-samples, but are stronger in the post-financialization periods.
- Results remain when Fama-Macbeth regressions are used.

Selected References

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