Do Behavioral Biases Affect Prices?

Coval and Shumway (2005)

March 22, 2019

Introduction

Key Points

- Paper documents evidence for behavioral biases among Chicago Board of Trade
- Traders in this market are highly loss-averse, assume above average risk to combat earlier losses
- This behavior has important price impact on afternoon prices
- Prices set by loss-averse traders are reversed significantly more quickly than by unbiased traderes

Introduction

Overview

Testing for behavior biases is hard - Many different behavioral theories rooted in Psychology - Models cannot be easily tested with aggregare data - Detailed data is hard to get - Hard to measure investor horizon - Hard to distinguish from noise trading - Challenging to link bias impact on prices

Introduction

Setting - Chicago Board of Traders

- Bias should show up:
  - Traders exchange $200 million worth of contracts per day
  - Traders participate in 95% of all trades
- Trades are done by market makers - with personal accounts
- Trading Horizon is clear - most traders close position every day

Introduction

Roadmap

1. Look for signs of traders taking either greater or lesser risk as profits grow
2. Split trading day and compare trading in morning and evening
3. Examine traders to see if they are more likely to move afternoon prices following morning losses
4. Examine permance of price moves spurred by morning losses
5. Examine whether prices exhibit greater volatility in afternoons following morning losses

Introduction

Bias in Beliefs

1. Self-Attribution (overconfidence)
2. Conservativeness and Representativeness

Bias in Preferences

1. Prospect Theory
   - Profits near zero lead to high subsequent risk aversion
   - Risk-seeking behavior present in regon of losses
2. House-money Effect

Hypothesis and Assumptions

Hypothesis: There is no relationship between morning returns and afternoon risk-taking

Assumptions

1. Efficient Markets
2. Rational Traders
3. Traders have Von Neumann-Morgenstern utility functions
4. Negligble Wealth Effects
5. Margin constraints unimportant
6. Raders' compensationand reputational concerns neutral
7. Profit opportunities are uncorrelated across trading day

Hypothesis

Alternative 1

Self-attribution bias, representativeness heuristic, and house money effect predict morning returns will be positively related to afternoon risk-taking

Alternative 2

Risk-seeking in losses predicts the null will be rejected if morning returns are negatively related to afternoon risk-taking

Data

- CBOT T-Bond futures 1998
  - Includes identifiers for buer and seller, price, time of transaction, and on whose behalf
- 426 Traders using their own personal account.
- To measure profit and inventory, assume each trader closes position at end of day (no beginning inventory)
  - Use inventory controls and winsorize
- Profit computed by looking at market value of inventory times contracts outstanding, added to local's running profit figure

Data

Measuring Risk

- Use historical price change data, second-by-second time and sales from Future Industry Institute Data Center
- Calculate front-month futures contract prices at the beginning of each minute from 1989 to 1998
- Fit Ordered Logit Regression to get probability of various portential abs price changes over next minute
- Use fitted values to construct an expected absolute price change for each minute of each full trading day in 1998.
- Calculate trader's risk by multiplying each minute's risk measure by the trader's position at the beginning of the mintue.
- Adjust trader's risk for the minute by any changes in inventory (and therefore risk) in the minute
- Calculate cumulative risk - Total Dollar Risk

Method

- Split trading day into two periods: before 11:00 am and after
- For each trader, calculate morning and evening profits
- Also, calculat total dollar risk, number of trades and average trade size
- Normalize traders profits and risk-taking to account for heterogeneity in margin constraints

Table 1

Panel A: Statistics by Trader-Day

	Morning			Afternoon		
Variable	Mean	Median	St. Dev.	Mean	Median	St. Dev.
All Trader-Days ($N = 82{,}595$) Raw Data						
Profits	1808.33	750.00	171848.13	661.78	187.50	113964.28
Number of trades	116.62	88.00	105.37	73.25	52.00	72.95
Average trade size	10.03	4.84	19.17	9.35	4.53	18.27
Total dollar risk	9641.46	1150.00	57540.27	10876.76	1242.83	75133.82
Price-setting trades	0.202	0.000	0.514	0.327	0.000	0.643
Traders with Profitable Mornings ($N = 55{,}877$) Normalized by Trader						
Profits	0.467	0.276	0.574	0.095	0.067	0.733
Number of trades	−0.035	−0.159	0.986	−0.066	−0.234	0.980
Average trade size	−0.063	−0.222	0.967	−0.046	−0.213	0.989
Total dollar risk	−0.122	−0.317	0.776	−0.100	−0.335	0.801
Price-setting trades	−0.009	−0.188	0.601	−0.017	−0.128	0.467
Traders with Losing Mornings ($N = 26{,}718$) Normalized by Trader						
Profits	−0.563	−0.273	0.727	0.082	0.067	0.915
Number of trades	0.066	−0.065	1.013	0.124	−0.036	1.016
Average trade size	0.119	−0.081	1.040	0.086	−0.114	1.006
Total dollar risk	0.180	−0.146	0.993	0.141	−0.205	0.997
Price-setting trades	0.018	−0.171	0.619	0.036	−0.116	0.526

Panel B: Statistics by Day

Variable	Mean	St. Dev.	Minimum	Maximum
Afternoon price changes	621.8703	215.383	195.00	1582.00
Fraction with morning losses	0.3238	0.049	0.20	0.50
Fraction of loss-averse traders with losses	0.3305	0.055	0.19	0.50
Fraction of price-setting traders with losses	0.3230	0.051	0.19	0.49

Morning Losses Lead to Afternoon Risk-Taking

Regress Afternon risk-taking on morning profits:

$$\mathbf{RISK}^{\mathbf{A}}_{i,t} = \alpha + \beta_{\pi}\pi^{\mathbf{M}}_{i,t} + \beta_I|\mathbf{INV}^{\mathbf{M}}_{i,t}| + \beta_{\pi I}\pi^{\mathbf{M}}_{i,t} \cdot |\mathbf{INV}^{\mathbf{M}}_{i,t}| + \beta_R\mathbf{RISK}^{\mathbf{M}}_{i,t} + \varepsilon_{i,t}$$

where

- $\pi^{M}_{i,t}$ is trader i's data t morning profit
- $\left|INV^{M}_{i,t}\right|$ is abs value of trader i's outstanding position at the end of the morning on date t.
- $RISK^{M}_{i,t}$ is trader i's morning risk measured on date t

They also used Pooled Regression and Fama-MacBeth

Results

- A one standard deviation decrease in morning profits leads the average trader to to place more afternoon trades than normal
- Higher inventory positions midday associated with higher afternoon risk
- Traders who assume significant risk in the morning continue to do so in afternoon
- Consistent results when top N% of traders with morning losses compared to only top N% of traders with greatest morning gains

Results - Table 2

$$\mathrm{RISK}^{\mathrm{A}}_{i,t} = \alpha + \beta_{\pi}\pi^{\mathrm{M}}_{i,t} + \beta_{I}|\mathrm{INV}^{\mathrm{M}}_{i,t}| + \beta_{\pi I}\pi^{\mathrm{M}}_{i,t} \cdot |\mathrm{INV}^{\mathrm{M}}_{i,t}| + \beta_{R}\mathrm{RISK}^{\mathrm{M}}_{i,t} + \varepsilon_{i,t}$$

Method	α	β_{π}	β_{I}	$\beta_{\pi I}$	β_{R}
Panel A: Dependent Variable: Afternoon Number of Trades					
Pooled OLS	0.0187	−0.1349	0.0313	0.056	0.2361
	(4.88)	(−23.38)	(7.26)	(12.99)	(61.66)
FM by trader	0.0315	−0.1173	0.0511	0.058	0.2182
	(2.35)	(−4.62)	(2.35)	(7.49)	(25.7)
FM by date	−0.0143	−0.1874	0.0378	0.0588	0.1499
	(−0.49)	(−27.89)	(7.27)	(10.33)	(23.3)
Fixed effects PCSE	–	−0.1362	0.03395	0.0547	0.2106
	–	(−17.90)	(5.44)	(11.36)	(12.07)
Panel B: Dependent Variable: Afternoon Average Trade Size					
Pooled OLS	0.0098	−0.0691	0.0606	0.0203	0.2159
	(2.53)	(−11.95)	(13.67)	(4.69)	(54.89)
FM by trader	−0.0045	−0.1013	0.0421	0.0227	0.2056
	(−0.27)	(−3.44)	(1.41)	(2.75)	(23.79)
FM by date	0.0095	−0.1076	0.0582	0.0290	0.1726
	(0.65)	(−11.86)	(9.31)	(3.83)	(27.58)
Fixed effects PCSE	–	−0.7061	0.0594	0.0189	0.1964
	–	(−11.16)	(11.70)	(4.18)	(31.28)

Results - Table 2

$$\text{RISK}^{\text{A}}_{i,t} = \alpha + \beta_{\pi}\pi^{\text{M}}_{i,t} + \beta_{I}|\text{INV}^{\text{M}}_{i,t}| + \beta_{\pi I}\pi^{\text{M}}_{i,t} \cdot |\text{INV}^{\text{M}}_{i,t}| + \beta_{R}\text{RISK}^{\text{M}}_{i,t} + \varepsilon_{i,t}:$$

Panel C: Dependent Variable: Afternoon Total Dollar Risk					
Pooled OLS	0.0000	−0.0079	0.5802	0.0134	0.3001
	(0.02)	(−3.00)	(195.70)	(6.80)	(98.2)
FM by trader	0.0015	−0.0107	0.6208	0.0170	0.2555
	(1.55)	(−2.41)	(60.93)	(4.27)	(29.81)
FM by date	−0.0007	−0.0161	0.5812	0.0235	0.2868
	(−0.12)	(−3.91)	(63.97)	(4.75)	(39.98)
Fixed effects PCSE	–	−0.0091	0.5794	0.0139	0.2990
	–	(−2.77)	(157.09)	(6.34)	(70.17)
Panel D: Dependent Variable: Afternoon Total Dollar Risk Matched Percentiles of Winners and Losers					
Pooled OLS	−0.0003	−0.0078	0.5925	0.0139	0.2933
	(−0.17)	(−2.83)	(181.63)	(6.75)	(87.31)
FM by trader	−0.0001	−0.0095	0.6342	0.017	0.2501
	(−0.1)	(−2.1)	(61.62)	(4.31)	(28.65)
FM by date	−0.0014	−0.0151	0.593	0.0232	0.2811
	(−0.22)	(−3.57)	(65.03)	(4.64)	(38.8)
Fixed effects PCSE	–	−0.0085	0.5913	0.0143	0.2927
	–	(−2.58)	(147.79)	(6.38)	(63.92)

Results - Sorting

Table III

Table III

Morning Profits and Afternoon Risk-Taking: Double Sorts

This table reports the average afternoon risk-taking by locals at the CBOT when traders are sorted on each day into bins according to morning profits and morning risk-taking, and where morning risk-taking is measured as the number of trades, average trade size, and total dollar risk. Traders are sorted into quintiles according to morning profits and then, within each quintile, are sorted into quintiles according to morning risk-taking. Afternoon risk-taking measures are then averaged across traders in each cell. Standard errors are in parentheses. All variables that depend on measures of inventory are Winsorized at the 1 and 99% levels. The sample contains 82,595 local-days.

Panel A: Afternoon Number of Trades

	Morning Number of Trades				
Morning Profits	1 (low)	2	3	4	5 (high)
1 (low)	−0.0498	0.0359	0.1385	0.1679	0.4264
	(0.0226)	(0.0199)	(0.0185)	(0.0188)	(0.0197)
2	−0.0639	−0.0218	0.0169	0.145	0.2965
	(0.0157)	(0.0182)	(0.0191)	(0.0214)	(0.024)
3	−0.1539	−0.0899	−0.0088	0.0288	0.2229
	(0.0159)	(0.0172)	(0.019)	(0.0206)	(0.0244)
4	−0.2404	−0.1891	−0.0818	−0.0283	0.0852
	(0.0182)	(0.017)	(0.0181)	(0.0186)	(0.021)
5 (high)	−0.2983	−0.2088	−0.1626	−0.0597	0.0578
	(0.0227)	(0.0189)	(0.0184)	(0.018)	(0.0184)

Results - Logit Model

Table IV

Binary Results for Morning Profits and Afternoon Risk-Taking

This table reports the results of a number of different logit models relating morning profits to afternoon risk-taking by locals at the CBOT. All models measure both morning profits and afternoon risk in a binary form, and the logit models have the basic form,

$$\text{Prob}\left(\text{RISK}^{\text{A}}_{i,t} > 0\right) = \frac{\exp X'\beta}{1 + \exp X'\beta},$$

where

$$X'\beta = \alpha - \beta_\pi I\left(\pi^{\text{M}}_{i,t} < 0\right) + \beta_I \left|\text{INV}^{\text{M}}_{i,t}\right| + \beta_{\pi I} I\left(\pi^{\text{M}}_{i,t} < 0\right) \cdot \left|\text{INV}^{\text{M}}_{i,t}\right| + \beta_R \text{RISK}^{\text{M}}_{i,t}.$$

The t-statistics are in parentheses. All variables that depend on measures of inventory are Winsorized at the 1 and 99% levels. In Panel D, only the top (i.e., most profitable) X% of all traders on a given day is included in the regression, where X is the fraction of traders with losses on that day. In Panels A through C, the sample contains 82,595 local-days. In Panel D the sample contains 65,061 local-days.

Method	α	β_π	β_I	$\beta_{\pi I}$	β_R
Panel A: Prob(Afternoon Number of Trades > Mean Trades)					
Pooled logit	0.375	−0.2875	−0.0801	0.0537	−0.3865
	(1384.93)	(−286.97)	(−41.82)	(11.71)	(−2107.91)
FM by trader	0.2766	−0.1989	−0.3139	0.3088	−0.4017
	(1.54)	(−1.02)	(−1.11)	(1.11)	(−14.87)
FM by date	0.553	−0.3466	−0.0947	0.0844	−0.331
	(8.58)	(−11.45)	(−4.48)	(1.88)	(−17.94)

Results - Logit Model

$$\text{Prob}\left(\text{RISK}^{\text{A}}_{i,t} > 0\right) = \frac{\exp X'\beta}{1+\exp X'\beta},$$

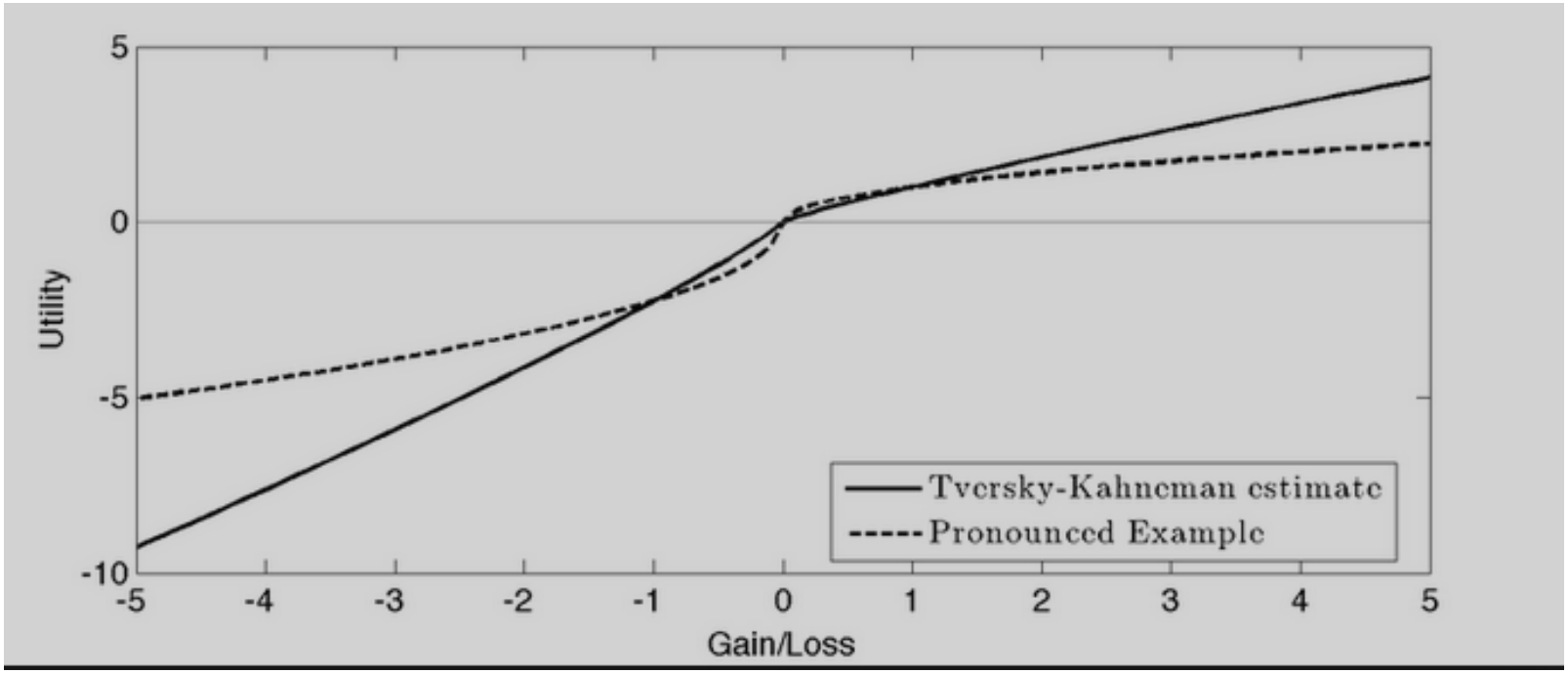
where

$$X'\beta = \alpha - \beta_{\pi} I\left(\pi^{\text{M}}_{i,t} < 0\right) + \beta_I \left|\text{INV}^{\text{M}}_{i,t}\right| + \beta_{\pi I} I\left(\pi^{\text{M}}_{i,t} < 0\right) \cdot \left|\text{INV}^{\text{M}}_{i,t}\right| + \beta_R \text{RISK}^{\text{M}}_{i,t}.$$

Panel B: Prob(Afternoon Average Trade Size > Mean Size)					
Pooled logit	0.4581	−0.1528	−0.1083	0.0118	−0.4223
	(2015.13)	(−78.94)	(−71.54)	(0.51)	(−2070.04)
FM by trader	0.6396	−0.3140	0.1272	−0.2697	−0.488
	(4.39)	(−2.07)	(0.60)	(−1.27)	(−15.99)
FM by date	0.5192	−0.2012	−0.1183	−0.0111	−0.3615
	(15.59)	(−8.8)	(−6.11)	(−0.39)	(−26.17)
Panel C: Prob(Afternoon Total Dollar Risk > Mean Risk)					
Pooled logit	−0.9595	0.2032	2.0773	−0.5024	1.4089
	(−70.18)	(9.34)	(67.1)	(−11.6)	(60.03)
FM by trader	−0.7171	0.0572	4.4364	1.1028	1.6801
	(−18.74)	(0.97)	(11.52)	(1.35)	(20.21)
FM by date	−0.9726	0.191	2.516	−0.4388	1.5145
	(−31.06)	(6.57)	(30.94)	(−5.12)	(36.12)
Panel D: Regressions Requiring Matched Percentiles of Winners and Losers Prob(Afternoon Total Dollar Risk > Mean Risk)					
Pooled logit	−0.9001	0.146	2.1477	−0.5587	1.3616
	(−55.94)	(6.27)	(59.45)	(−11.92)	(54.82)
FM by trader	−0.7107	0.056	6.1548	−0.7123	1.7579
	(−11.00)	(0.70)	(10.91)	(−0.80)	(15.81)
FM by date	−0.9124	0.1354	2.693	−0.6009	1.4724
	(−26.96)	(4.43)	(28.95)	(−6.02)	(37.2)

Semiparametric Regression

Use semi-parametic model to account for kinks:



Setup

$$\mathrm{RISK}^{\mathrm{A}}_{i,t} = \alpha + \sum_{j=1}^{20} \beta_{\pi,j} D_{i,j,t} + \beta_I \left|\mathrm{INV}^{\mathrm{M}}_{i,t}\right| + \sum_{j=1}^{20} \beta_{\pi I,j} D_{i,j,t} \cdot \left|\mathrm{INV}^{\mathrm{M}}_{i,t}\right| + \beta_R \mathrm{RISK}^{\mathrm{M}}_{i,t} + \varepsilon_{i,t},$$

Figure 1:

- Rank traders each day according to their normalized morning profit and assign them to one of 20 profitability groups
- Conduct daily cross-sectional regressions with model above
- Dummy variable D equals one if trader i's morning profit ranks in group j on the date t.
- Average the cross-sectional regression coefficients across time, compute standard errors

Semiparametric Regression

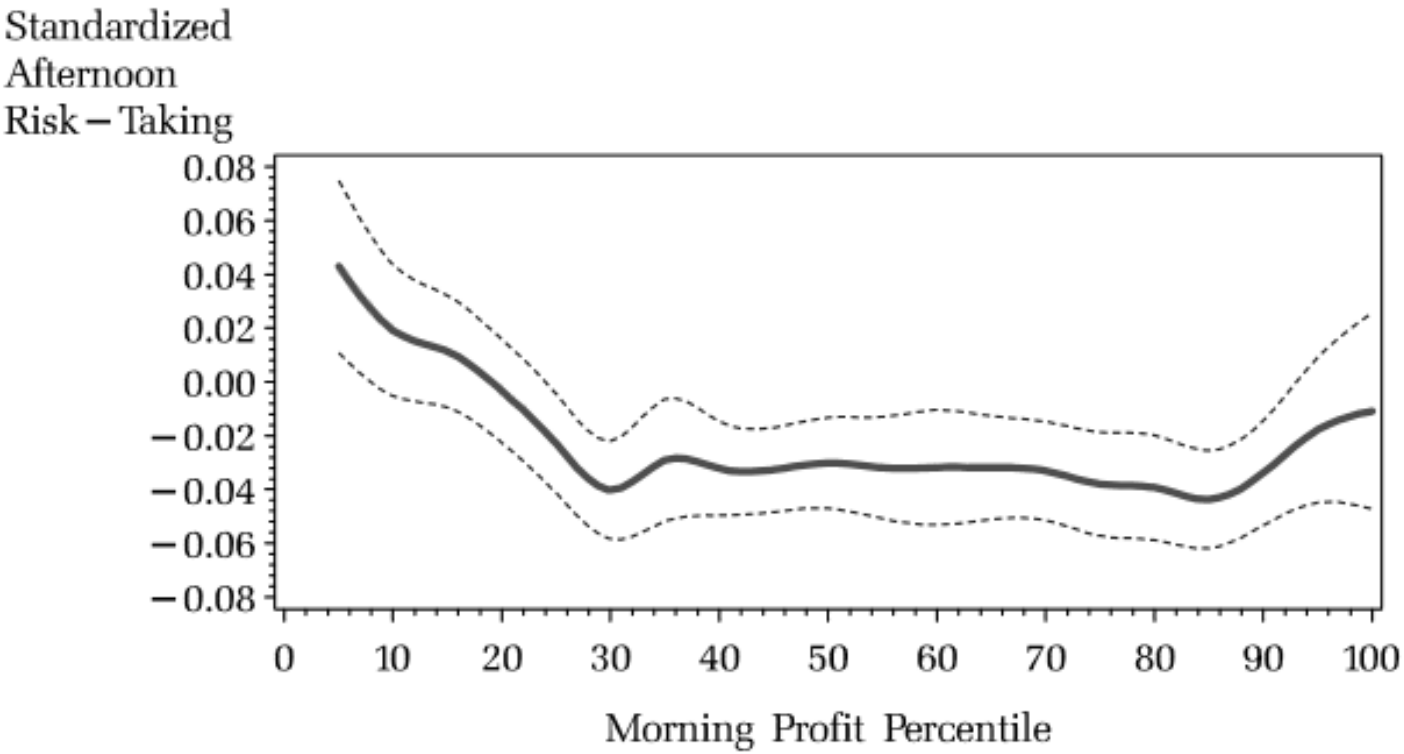


Figure 1. Morning profit percentile and afternoon risk-taking. This figure plots the time-series averages of 236 daily cross-sectional semiparametric regressions of afternoon total dollar risk on morning profit percentile. The regressions are kernel-smoothed and the dashed lines reflect two standard error bands of the time series-averaged regressions.

Figure 2: