The Unintended Consequences of Rebalancing

Campbell R. Harvey[1], Michele G. Mazzoleni[2] and Alessandro Melone[3]

[1]Duke University & NBER [2]Capital Group [3]The Ohio State University

EDHEC Speaker Series
February 10, 2026

Motivation

- Rebalancing is a widely used strategy implemented to align portfolio weights with target allocations
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  2. Most funds follow mechanical rebalancing rules that generate predictable pressures. Is there a risk of front-running?

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→ **Yes** & quantify the **economic implications**

This Paper in One Slide

- When stocks are overweight, funds sell stocks/buy bonds, leading to **17 bps decrease** in equity returns of and **3 bps increase** in bond returns
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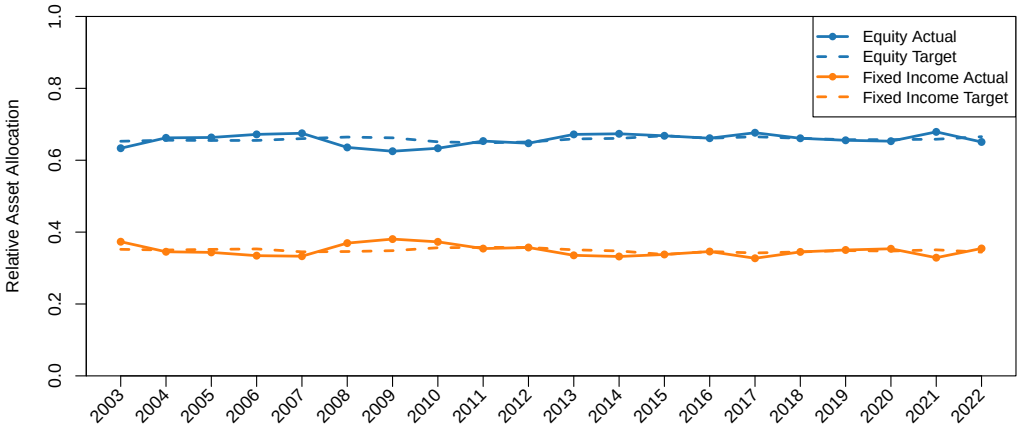
- We show that this effect is not explained by momentum, reversal, or other economic or behavioral factors
- Why do we care?
  - Novel evidence of **aggregate** price dynamics associated with rebalancing activity in the US
  - Mechanical rebalancing offers the opportunity to front-run trades and translates into economically significant costs for rebalancers

Actual Allocations and Targets of US Defined Benefit Pension Funds



Source: Center for Retirement Research, Boston College. Data available at Public Plans Data.

A Roundtable Discussion

- Preliminary results were shared with a global network of public pensions, representing approximately $2 trillion in AUM
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- All pensions reported systematic rebalancing schemes, varying between calendar- and threshold-based approaches
- Pensions funds were aware of aggregate rebalancing pressures
- Front-running risks were discussed, with some funds admitting to anticipating their own (and their peers') rebalancing
- Changing rebalancing policies is challenging due to institutional constraints
  - "It is easier for us to task our alpha desk with addressing this predictability than to try to convince our investment committee to change our rebalancing policy"

Rebalancing: Motivation and Measurement

Two Rule-Based Approaches to Rebalancing

- We put together extensive evidence on institutional rebalancing practices, complemented by broad survey data
- **Most US funds follow either a threshold or a calendar-based rebalancing approach**

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   - Rebalance when portfolio weights are more than δ% distant from their target
2. Calendar rebalancing
   - Rebalance regularly towards month- or quarter-end

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$\rightarrow$ Both mechanical schemes induce predictability

Extracting Predictive Rebalancing Signals (I)

- We simulate the daily dynamics of a 60/40 equity/bond portfolio
- We extract Threshold and Calendar rebalancing signals by measuring the **distance** of equity allocation from its target
- Threshold and Calendar signals are a function of past equity and bond market returns
- Suppose equity market is up 10% and bonds is flat, both signals increase by $66/106 - .60 = 2.26\%$

▸ More details ▸ Plots

Extracting Predictive Rebalancing Signals (II)

Two key parameters for the construction and testing of our rebalancing signals:

1. The rebalancing range δ associated with the construction of the Threshold signal:

$$Ret_{t+1} = \gamma_0 + \gamma_1 \text{Threshold Signal}_t^{\delta} + \epsilon_{t+1} \tag{1}$$

2. The range of days when we expect the Calendar signal to be relevant:

$$Ret_{t+1} = \beta_0 + \beta_1 \text{Calendar Signal}_t \cdot \text{Dummy}_t^{\text{N Days}} + \epsilon_{t+1} \tag{2}$$

where $\text{Dummy}_t^{\text{N Days}}$ is a dummy variable that takes the value of 1 during the last N-days of a month

Rebalancing Signals' Calibration

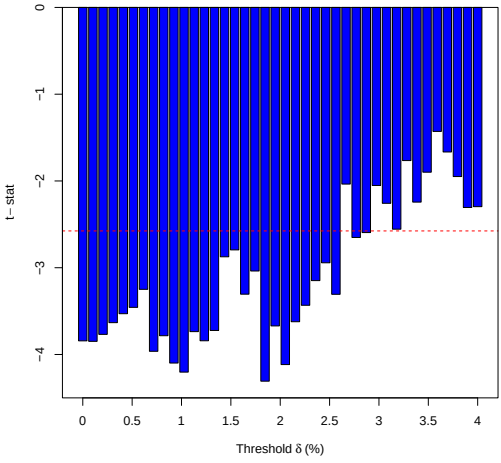

Figure: Threshold rebalancing

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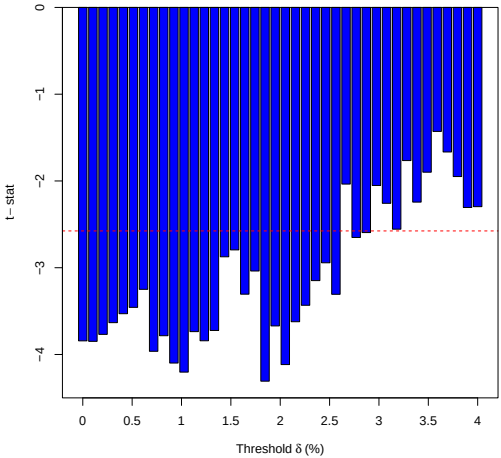

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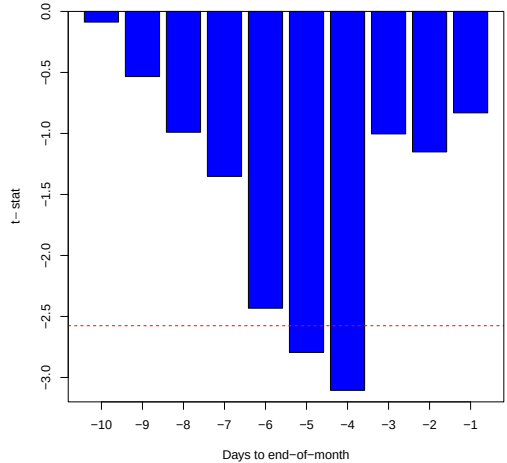

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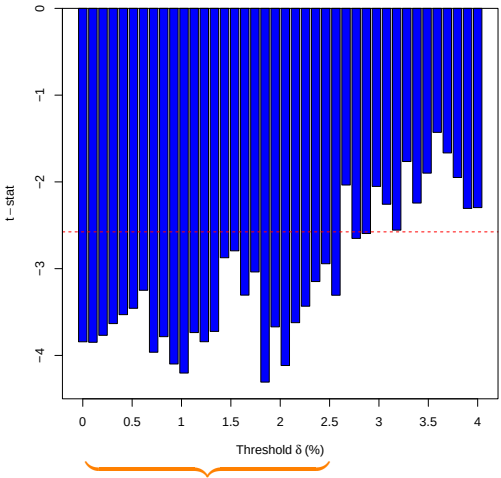

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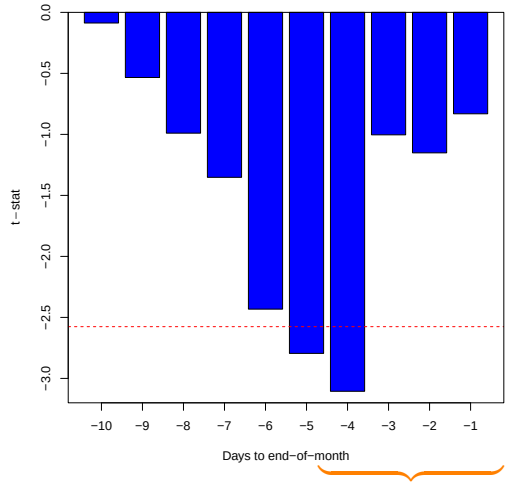

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Rebalancing and Aggregate Asset Dynamics

Predictive Regressions (Daily Data, 1997–2023)

	$(\text{Ret}^{S\&P500}_{t+1} - \text{Ret}^{10y}_{t+1})$		$\text{Ret}^{S\&P500}_{t+1}$		Ret^{10y}_{t+1}	
	(1)	(2)	(3)	(4)	(5)	(6)
Threshold	−0.4127***	−0.4202***	−0.3225***	−0.3301***	0.0902***	0.0901***
	(0.1104)	(0.1098)	(0.1015)	(0.1005)	(0.0244)	(0.0248)
Calendar ∗ week4	−0.3048***	−0.3053***	−0.2672***	−0.2676***	0.0376***	0.0377***
	(0.0804)	(0.0804)	(0.0753)	(0.0753)	(0.0126)	(0.0126)
Momentum	0.0023***	0.0024***	0.0017***	0.0018***	−0.0005***	−0.0005***
	(0.0006)	(0.0007)	(0.0005)	(0.0006)	(0.0001)	(0.0001)
Ret	−0.0147	−0.0113	−0.0211	−0.0179	−0.0064	−0.0067
	(0.0286)	(0.0284)	(0.0259)	(0.0256)	(0.0061)	(0.0061)
Controls	NO	YES	NO	YES	NO	YES
Observations	6,223	6,223	6,223	6,223	6,223	6,223
Adjusted R^2	0.0232	0.0244	0.0225	0.0242	0.0078	0.0072

▸ Data ▸ Price Pressures ▸ Index returns ▸ Different portfolio weights ▸ Reversals ▸ Other controls

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The Economic Costs of Current Rebalancing Policies (I)

1. We estimate the cost in percentage terms by multiplying the price impact by the average rebalancing trade:

$$\text{Annualized Costs} = \widehat{\text{Price Impact}} \times \text{Average Trade Size} \times \text{Trades per Year}$$

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$\rightarrow$ We use the average **8 bps** as our benchmark estimate

The Economic Costs of Current Rebalancing Policies (II)

- Economic context of 8 bps?
  - It is substantially more than what funds pay to access equity and bond markets
  - Pension funds acknowledge that this is a concern (see roundtable discussion)
  - As TDFs and balanced funds are expected to grow (e.g., Parker, Schoar, and Sun, 2023), these costs could increase

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2. We translate the cost in dollar terms by multiplying 8 bps by the estimated dollar size of rebalancers
   - \$20 trillion of assets may have been invested in public equity and debt → rebalancing cost is **\$16 billion per year**
   - 84 million of US households have a financial stake in the US retirement system → cost per household is about **\$200/year**

Quantity-Based Evidence on Rebalancing Pressures

- Rule-based rebalancing policies are a function of past returns
- We leverage four data sources to examine how our rebalancing signals relate to investors' trades
  1. CFTC: weekly futures net trading positions for hedgers (commercial traders) and speculators (non-commercial traders), 2006–2023
  2. Large Trader Position (LTPos): weekly net trading positions for asset managers and leveraged funds, 2009–2011
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- When equities are overweight (underweight) relative to bonds, pension plans sell (buy) equities, consistent with our interpretation

▸ Rebalancing and Investors' Trades

Further Validation of Rebalancing Signals

1. Seasonal patterns
2. Increased predictability over the past two decades
3. Predictability across large- vs. small-stocks
4. International evidence

Front-Running Rebalancers

Front-Running Rebalancers

- We construct a simple, implementable real-time trading strategy by combining Threshold and Calendar signals
- This strategy simulates the actions of an investor who, based on rebalancing signals, enters the equity and bond markets as a front-runner
  - Front-runners buy equities and sell bonds after bonds have outperformed and buy bonds and selling equities after equities have outperformed

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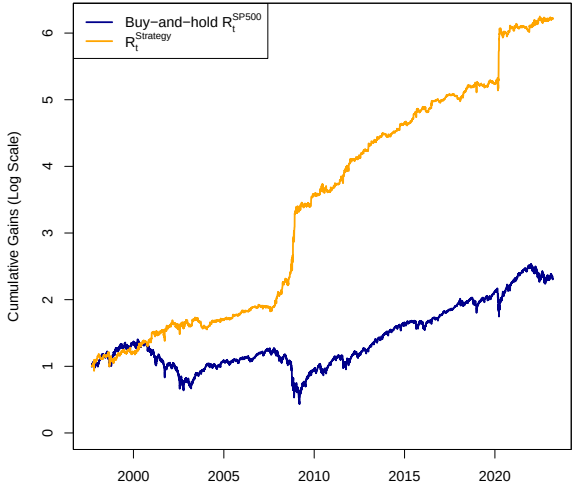
  - Front-runners buy equities and sell bonds after bonds have outperformed and buy bonds and selling equities after equities have outperformed
- This strategy generates a **Sharpe ratio of 1.08** and performs especially well during periods of high aggregate volatility/illiquidity

	liquidity risk		VIX	
	H	L	H	L
R_t^{Strategy}	17.96***	3.79**	16.50***	3.91***
	(3.33)	(1.85)	(3.44)	(1.11)

▸ More details ▸ Additional results

Front-Running Strategy Performance Over Time



Implications

Discussion

1. Let us make pensioners aware of rebalancing pressures
    - Mechanical rebalancing does not serve funds and pensioners well
    - Rebalancing costs are borne by balanced funds but remain hidden from individual investors focused on explicit fees
    - These costs may grow with the expansion of TDFs and other balanced strategies

Discussion

1. Let us make pensioners aware of rebalancing pressures
   - Mechanical rebalancing does not serve funds and pensioners well
   - Rebalancing costs are borne by balanced funds but remain hidden from individual investors focused on explicit fees
   - These costs may grow with the expansion of TDFs and other balanced strategies
2. Can rebalancing costs be reduced?
   - Designing more efficient rebalancing strategies requires theoretical, empirical, and institutional considerations and is left for future research
   - One could envision cost-mitigating strategies that avoid pre-scheduled trades, e.g., by introducing a random component to rebalancing (Huddart et al., 2001)
   - A strategy that preserves the rebalancing frequency while eliminating predictable price pressures reduces estimated costs to **0.6 basis points**

Conclusions

- Returning to our two questions:
  1. We find market-wide price effects related to rebalancing activity
  2. The predictability that mechanical rebalancing induces is costly for pensioners
- Our results are robust to a battery of controls detailed in the appendix
- Our findings underscore the importance of studying institutional investor trading to better understand asset price dynamics (Haddad and Muir, 2025)

Appendix: The Unintended Consequences of Rebalancing

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Measuring Rebalancing Activity

- Weight deviations from target represent natural signals for rebalancing activities
  - The larger the deviation, the greater the likelihood of rebalancing, as well as its potential magnitude
- We simulate a 60/40 equity/bond portfolio
  - 60% invested in front-contract E-Mini S&P500 futures
  - 40% invested in front contract 10-year Treasury note futures
- Distance from S&P500 target allocation provides the signal:

$$Distance_t = \left| \frac{w_{t-1}^{SP} \cdot (1 + R_t^{SP})}{w_{t-1}^{SP} \cdot (1 + R_t^{SP}) + w_{t-1}^{10Y} \cdot (1 + R_t^{10Y})} - 60\% \right|$$

Back

Calendar and Threshold Rebalancing Signals

- Calendar Signal
  - If t coincides with the last business day of a month, then $w_t^{SP,C} = 60\%$
  - Otherwise, $w_t^{SP,C} = \frac{w_{t-1}^{SP}(1+R_t^{SP})}{w_{t-1}^{SP}(1+R_t^{SP})+w_{t-1}^{10Y}(1+R_t^{10Y})}$

- Threshold Signal
  - If $Distance_t \geq \delta$, then $w_t^{SP,T} = 60\%$
  - Otherwise, $w_t^{SP,T} = \frac{w_{t-1}^{SP}(1+R_t^{SP})}{w_{t-1}^{SP}(1+R_t^{SP})+w_{t-1}^{10Y}(1+R_t^{10Y})}$
  - We average different threshold calibrations—for $\delta = 0$ to 2%—to capture actual policies of heterogeneous investors

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Data

- We use daily returns on S&P 500 and 10-year Treasury note futures from 1997-09-10 to 2023-03-17 (6,223 daily observations)
- Main controls:
  - Momentum: average the sign of 11 to 20, and 21, 42, 63, 126, and 252 trailing equity returns in excess of the 10-year treasury note
  - VIX: CBOE equity option-implied volatility index (divided by 100)
  - MOVE: US bond market option-implied volatility index (divided by 100)
  - Econ Uncertainty: news-based measure of economic policy uncertainty constructed in Baker, Bloom, and Davis (2016)
  - Econ Activity: Aruoba, Diebold, and Scotti (2009) real-time business conditions index
  - Sentiment: daily news-based sentiment index constructed in Shapiro, Sudhof, and Wilson (2022)

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Threshold and Rebalancing Signals

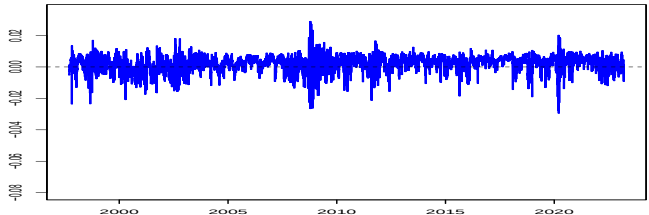
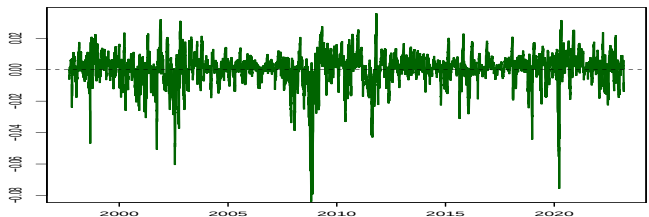


Figure: Threshold Signal



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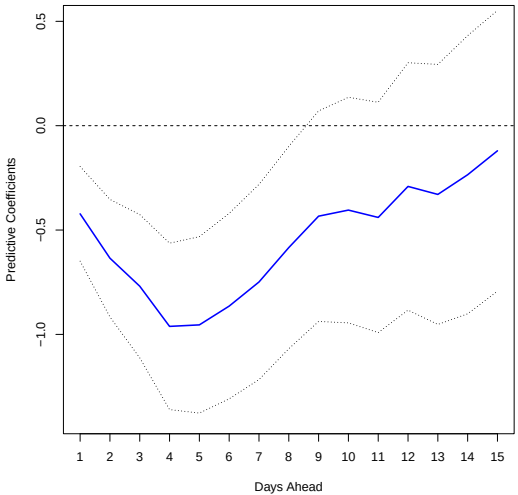
Temporary Price Pressures



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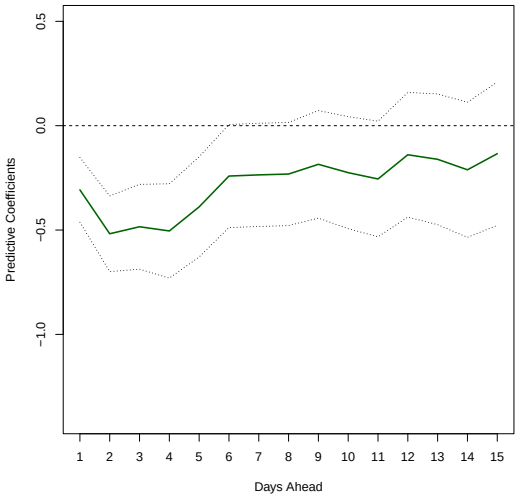


Figure: Calendar Signal ∗ Week4 Dummy

Correlation Matrix for Different Predictors

	Threshold	Calendar	Momentum	VIX	MOVE	Econ Uncertainty	Econ Activity	Sentiment
Threshold	1							
Calendar	0.602	1						
Momentum	0.672	0.676	1					
VIX	-0.348	-0.408	-0.496	1				
MOVE	-0.249	-0.243	-0.384	0.653	1			
EPU	-0.066	-0.132	-0.152	0.448	0.112	1		
ADS	0.069	0.156	0.194	-0.323	-0.192	-0.280	1	
NewsSentiment	0.094	0.134	0.255	-0.546	-0.318	-0.563	0.202	1

Back

Cross-Asset Predictive Regressions Using Index Returns

	Ret_{t+1}				
	(1)	(2)	(3)	(4)	(5)
Threshold	−0.3970***	−0.4048***	−0.4137***	−0.4131***	−0.4039***
	(0.1199)	(0.1203)	(0.1163)	(0.1182)	(0.1195)
Calendar ∗week4	−0.3189***	−0.3199***	−0.3187***	−0.3194***	−0.3194***
	(0.0866)	(0.0863)	(0.0863)	(0.0863)	(0.0864)
VIX		0.0117**			0.0108
		(0.0060)			(0.0070)
MOVE		−0.0023**			−0.0021*
		(0.0012)			(0.0012)
EPU			0.0007**		0.0003
			(0.0003)		(0.0004)
ADS			0.0000		0.0001
			(0.0002)		(0.0002)
Sentiment				−0.0018	0.0003
				(0.0013)	(0.0013)
Observations	6,223	6,223	6,223	6,223	6,223
Adjusted R^2	0.0238	0.0258	0.0247	0.0242	0.0255

The Role of Reversal

	Ret_{t+1}				
	(1)	(2)	(3)	(4)	(5)
Threshold		-0.4063^{***}		-0.5448^{***}	-0.5298^{***}
		(0.1231)		(0.1112)	(0.1501)
Calendar $*$week4		-0.3104^{***}		-0.2817^{***}	-0.2835^{***}
		(0.0812)		(0.0968)	(0.0982)
Short-Term Reversal	-0.0366^{***}	-0.0140			-0.0041
	(0.0136)	(0.0195)			(0.0237)
Long-Term Reversal			-0.0003	-0.0001	-0.0001
			(0.0004)	(0.0004)	(0.0004)
Observations	6,470	6,223	5,215	5,215	5,215
Adjusted R^2	0.0054	0.0235	-0.0001	0.0258	0.0256

Back

Different Portfolio Weights

	Ret_{t+1}
Threshold	-0.8008***
	(0.179)
Calendar $*$week4	-0.6061***
	(0.162)
Observations	6,223
Adjusted R^2	0.0220

Back

Alternative Controls

	Ret_{t+1}		
	(1)	(2)	(3)
Threshold	-0.4669^{***}	-0.4514^{***}	-0.4523^{***}
	(0.1071)	(0.1638)	(0.1592)
Calendar $*$week4	-0.2986^{***}	-0.3971^{***}	-0.3596^{***}
	(0.0801)	(0.1303)	(0.1325)
ra^{BEX}	0.0012		-0.0069
	(0.0008)		(0.0184)
unc^{BEX}	-0.0012		-0.0041^{**}
	(0.0011)		(0.0020)
FEARS		0.0009	0.0020
		(0.0007)	(0.0016)
VIX			-0.0014
			(0.0012)
MOVE			0.0007
			(0.0007)
Observations	6,121	3,147	3,122
Adjusted R^2	0.0314	0.0299	0.0454

Back

Seasonal Patterns

	Ret_{t+1}		
	(1)	(2)	(3)
Threshold	-0.3326^{***}	-0.4127^{***}	-0.4520^{***}
	(0.1073)	(0.1097)	(0.1249)
Calendar	-0.0760	0.0580	0.0693
	(0.0572)	(0.0694)	(0.0732)
Calendar $*$week4		-0.3048^{***}	-0.3345^{***}
		(0.0791)	(0.0937)
Threshold $*$week4			0.1323
			(0.1567)
Observations	6,223	6,223	6,223
Adjusted R^2	0.0124	0.0232	0.0233

Long-Term Evidence

	Ret_{t+1}		
	(1)	(2)	(3)
Sample	1961-2023	1961-1997	1997-2023
Threshold	-0.1809^{***}	-0.0157	-0.3685^{***}
	(0.0620)	(0.0576)	(0.1103)
Calendar $*$week4	-0.1536^{***}	-0.0284	-0.2569^{***}
	(0.0471)	(0.0596)	(0.0670)
Observations	15,291	8,870	6,421
Adjusted R^2	0.0053	0.0204	0.0170

Back

Long-Term Evidence

	Ret_{t+1}			
	(1)	(2)	(3)	(4)
Sample	1961-2023	1961-1997	1997-2023	1997-2025
Threshold	-0.1809^{***}	-0.0157	-0.3685^{***}	-0.3808^{***}
	(0.0620)	(0.0576)	(0.1103)	(0.1112)
Calendar $*$week4	-0.1536^{***}	-0.0284	-0.2569^{***}	-0.2849^{***}
	(0.0471)	(0.0596)	(0.0670)	(0.0779)
Momemtum	0.0013^{***}	0.0004	0.0020^{***}	0.0021^{***}
	(0.0003)	(0.0003)	(0.0005)	(0.0005)
Ret	0.0216	0.1433^{***}	-0.0144	-0.0248
	(0.0192)	(0.0245)	(0.0280)	(0.0275)
Observations	15,291	8,870	6,421	6,839
Adjusted R^2	0.0053	0.0204	0.0170	0.0220

Back

International Equity

	Ret_{t+1}				
	(1)	(2)	(3)	(4)	(5)
Threshold	−0.2711***	−0.2764***	−0.2727***	−0.2755***	−0.2739***
	(0.0870)	(0.0857)	(0.0870)	(0.0868)	(0.0865)
Calendar ∗week4	−0.2062***	−0.2059***	−0.2060***	−0.2065***	−0.2059***
	(0.0535)	(0.0539)	(0.0536)	(0.0535)	(0.0539)
VIX		0.0036			0.0013
		(0.0043)			(0.0047)
MOVE		−0.0015*			−0.0011
		(0.0008)			(0.0009)
Econ Uncertainty			0.0004**		0.0004
			(0.0002)		(0.0003)
Econ Activity			0.0001		0.0001
			(0.0002)		(0.0002)
Sentiment				−0.0008	−0.0001
				(0.0009)	(0.0009)
Observations	6,098	6,096	6,096	6,096	6,096
Adjusted R^2	0.0254	0.0262	0.0263	0.0255	0.0265

Back

Weekly Trades and Rebalancing Signals

	Hedgers Q_{t+1}		Speculators Q_{t+1}	
	(1)	(2)	(3)	(4)
Threshold	-0.5346^{**}	-0.4967^{*}	0.5855^{**}	0.4849^{*}
	(0.2658)	(0.2638)	(0.2545)	(0.2625)
Calendar $*$week4	-0.7265^{***}	-0.7559^{***}	0.3475^{*}	0.3672^{*}
	(0.2210)	(0.2195)	(0.1955)	(0.1998)
Hedgers Q_t		-0.0730^{**}		
		(0.0358)		
Speculators Q_t				-0.1093^{***}
				(0.0379)
Observations	863	862	863	862
Adjusted R^2	0.0316	0.0358	0.0437	0.0546

Rebalancing across Equity Indices

	(1) R1K / R2K	(2) R1K Value / R1K Growth
Threshold	-0.2054^{***}	-0.0339
	(0.0597)	(0.0478)
Calendar $*$ week4	-0.1174^{*}	-0.0678
	(0.0683)	(0.0654)
Observations	4,175	4,175
Adjusted R^2	0.0094	0.0023

Back

Constructing a Front-Running Strategy

- The trading strategy takes a long position in an S&P 500 futures contract and a short position in a 10-year Treasury note futures contract as follows:

$$R_t^{\text{Strategy}} = (R_t^{\text{SP500}} - R_t^{10T}) \cdot w_t^{\text{Strategy}}$$

  where the portfolio weight w_t^{Strategy} is defined as the average of modified versions of the Threshold and Calendar signals

- The Threshold signal is rescaled to

$$-\frac{\text{Threshold Signal}_t}{1.5\%}$$

  to ensure that both rebalancing signals contribute approximately equal risk to the trading strategy

- We take the negative of the signal, since a positive Threshold signal indicates that S&P 500 is overweight relative to the 10-year Treasury note

Front-Running Trading Strategy Performance

Panel A: Descriptive Statistics

	Ex. Returns (in % p.a.)	Volatility (in % p.a.)	Sharpe Ratio	Skewness
R_t^{SP500}	7.11	20.05	0.35	-0.08
R_t^{10T}	2.92	6.13	0.48	0.03
R_t^{Strategy}	10.20	9.17	1.11	5.23

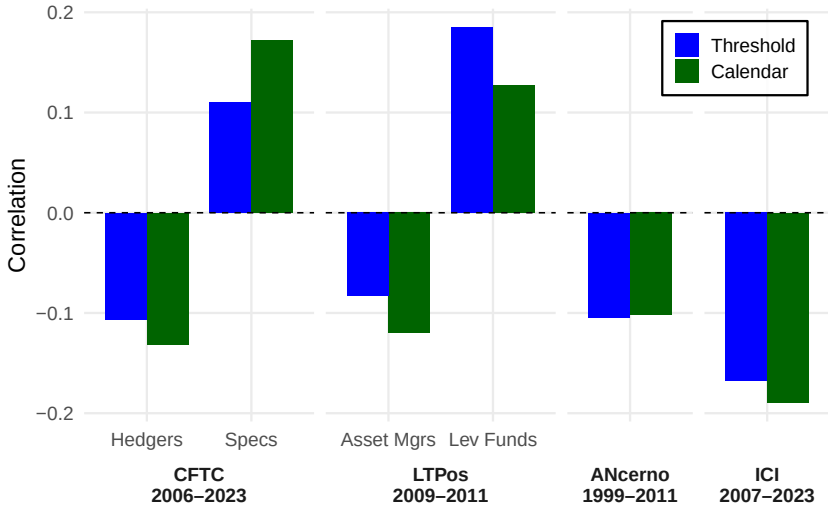
Panel B: Alphas (in % p.a.)

	CAPM	C4	FF5	HXZ
α	9.61***	9.64***	9.49***	9.43***
	(1.77)	(1.78)	(1.74)	(1.75)

Panel C: High- and Low-Friction Periods (in % p.a.)

	ivol		liquidity risk		VIX		MOVE		Econ Uncertainty	
	H	L	H	L	H	L	H	L	H	L
R_t^{Strategy}	15.68***	5.09***	17.96***	3.79**	16.50***	3.91***	14.85***	5.55***	15.16***	5.24***
	(3.44)	(1.28)	(3.33)	(1.85)	(3.44)	(1.11)	(3.32)	(1.43)	(3.26)	(1.56)

Rebalancing Signals and Investors' Trading Positions



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