U.S. Stock Market

A Historical Analysis & Framework for Regime-Adaptive Investing

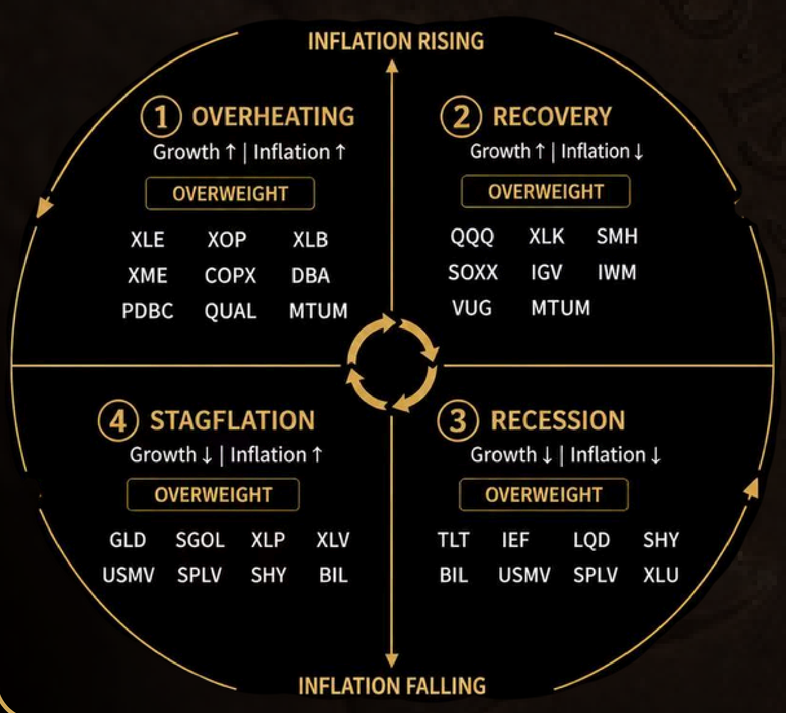
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Historical Data Analysis

Six major U.S. bull & bear market

Period	Regime	Event	S&P 500
1921–1929	BULL	Roaring Twenties	+396%
1929–1932	BEAR	Great Depression Deflation	-86%
1982–2000	BULL	Tech-Driven Long Bull Disinflation	+1,263%
2000–2002	BEAR	Dot-Com Bust Tech valuation bubble	-49%
2007–2008	BEAR	Global Financial Crisis Credit leverage unwind	-57%
2009–now	BULL	QE Supercycle Monetary expansion	+1,263%

Regime Identification



Key Indicators

- CPI YoY
- PPI YoY
- Real GDP
- ISM PMI
- Unemployment Rate
- Yield Curve
- Credit Spread
- Financial Conditions Index

Enhanced Merrill Lynch Clock

Asset Ranking

We estimate the probability of each market regime using **Softmax**.

Linear Scoring

For each regime $k \in \{1,\dots,R\}$:

$$s_{t,k} = w_k^T x_t + b_k$$

x_t: macro feature vector
w_k: weight vector for regime k
b_k: bias term for regime k

Calculates raw match scores between real-time data and each market regime. Raw scores are unbounded and cannot act as probabilities.

Softmax Probability

Convert scores to probabilities:

$$P(k|x_t) = \frac{e^{s_{t,k}}}{\sum_{j=1}^{R} e^{s_{t,j}}}$$

where $\sum_{k=1}^{R} P(k|x_t) = 1$

Converts unbounded scores into standardized probabilities that sum to 1; all regimes retain non-zero likelihood.

Weight asset historical risk-adjusted returns by readable regime probabilities to generate dynamic, allocation rankings.

Investor Psychology

We model the dynamic interaction between Risk-On (R) and Risk-Off (S) investors as a continuous-time system.

Lotka-Volterra Model

$$\frac{dR}{dt} = \alpha R - \beta RS$$
$$\frac{dS}{dt} = \delta RS - \gamma S$$

R: proportion of Risk-On investors
S: proportion of Risk-Off investors
α: natural growth rate of risk-seekers
γ: natural decay rate of fear
β,δ: impact of optimism/fear on each other

Behavioral Biases

- **Loss Aversion**: People feel loss more intensely than gains.
- **Herd Mentality**: Investors blindly follow mainstream market trends.
- **Anchoring Bias**: People rely on old information to judge markets.
- **Sentiment Mean Reversion**: Extreme market optimism or pessimism will fade.

Portfolio Allocation

Combine regime probabilities and investor states to form asset weights.

$$w_{t,k} = \sum_{k=1}^{R} P(k|x_t) \cdot A_{k,t}(R_t, S_t)$$

w_t: weight of asset i at time t
R_t, S_t: investor state from LV model

$A_{k,t}$: target weight of asset i under regime k (adjusted by R_t, S_t)

Programmatic Backtest

Logical Framework



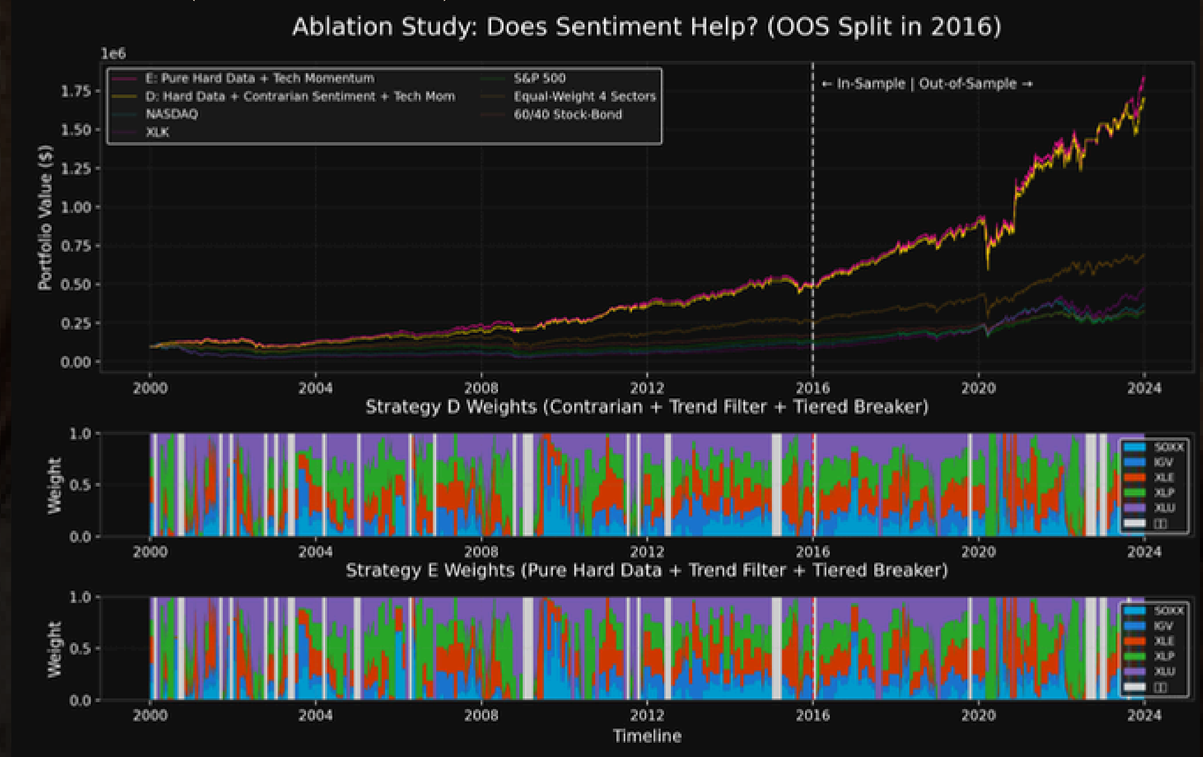
Implementation

```
if r_xlu_d > RECESSION_HARD:
    base_d = {'SOXX': 0.0, 'IGV': 0.0, 'XLE': 0.0, 'XLP': 0.0, 'XLU': 0.0, 'CASH': 1.0}
elif r_xlu_d > RECESSION_SOFT:
    base_d = {'SOXX': 0.0, 'IGV': 0.0, 'XLE': 0.0, 'XLP': 0.0, 'XLU': 1.0, 'CASH': 0.0}
else:
    base_d = {
        'SOXX': r_xlk_d * sub_w[0], 'IGV': r_xlk_d * sub_w[1],
        'XLE': r_xle_d, 'XLP': r_xlp_d, 'XLU': r_xlu_d, 'CASH': 0.0
```

```
if i >= MOM_LOOKBACK:
    mom_end = i - MOM_SKIP
    mom_start = i - MOM_LOOKBACK
    if mom_end > mom_start and mom_end > 0:
        p_start = price_index.iloc[mom_start]
        p_end = price_index.iloc[mom_end]
        mom_ret = (p_end / p_start - 1).values
        sub_w = momentum_weights_by_return(mom_ret)
    else:
        sub_w = np.array([0.5, 0.5])
else:
    sub_w = np.array([0.5, 0.5])
```

```
history.append({
    'Date': date,
    'NAV_D': nav_d,
    'NAV_E': nav_e,
    'Bench_XLK': bench_xlk,
    'Bench_SP500': bench_sp500,
    'Bench_NASDAQ': bench_nasdaq,
    'Bench_EqualWeight': bench_equal_weight,
    'Bench_6040': bench_6040,
    'WD_SOXX': wd['SOXX'], 'WD_IGV': wd['IGV'], 'WD_XLE': wd['XLE'],
    'WD_XLP': wd['XLP'], 'WD_XLU': wd['XLU'], 'WD_CASH': wd['CASH'],
    'WE_SOXX': we['SOXX'], 'WE_IGV': we['IGV'], 'WE_XLE': we['XLE'],
    'WE_XLP': we['XLP'], 'WE_XLU': we['XLU'], 'WE_CASH': we['CASH'],
})
```

Results (2000–2024)



Strategy / Benchmark	In-Sample (2000-2015)			Out-of-Sample Blind Test (2016-2023)		
	Annualized Return	Sharpe Ratio	Max Drawdown	Annualized Return	Sharpe Ratio	Max Drawdown
D: Hard+Soft (Inverse)	10.4%	0.70	-38.8%	16.9%	0.95	-35.3%
E: Pure Hard Data	10.6%	0.68	-37.7%	17.6%	0.97	-35.3%
S&P 500	2.1%	0.21	-56.8%	11.4%	0.67	-33.9%
NASDAQ	1.2%	0.18	-77.9%	15.0%	0.74	-36.4%
Equal-Weight	6.3%	0.43	-46.9%	12.9%	0.77	-37.4%
60/40 Portfolio	3.4%	0.34	-36.6%	8.8%	0.81	-21.3%