

Evaluating Investment Strategies: Beyond Buy and Hold

A Quantitative Analysis of S&P 500 and Bond Yields

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March 2, 2025

Project Overview

- **Problem Space:**

- Investigating whether market-based probabilities can predict Bull/Bear markets
- Developing investment strategies that outperform buy-and-hold

- **Our Approach:**

- Market state classification using drawdown analysis
- Ensemble prediction models with attention mechanisms
- Advanced anomaly detection for risk management
- Combined Anomaly-Regime investment strategy

- **Key Results:**

- Superior returns to buy-and-hold (56.34% vs 52.97%)
- Significantly better risk-adjusted performance (Sharpe: 1.09 vs 0.58)
- Dramatically lower maximum drawdown (-10.28% vs -33.92%)
- Higher win rate (58.13% vs 54.12%)

Problem Statement

- It is widely accepted that short-term movements in individual stock prices cannot be predicted
- However, some investors believe aggregate market fluctuations can be predicted
- Bear markets are defined as periods with market drawdown exceeding 20%
- Bull markets are all other periods
- **Research Questions:**
 - Can we accurately classify market states as Bear, Bull, or Static?
 - Can market-based probabilities predict Bear/Bull markets?
 - Can we create a prediction-based investment strategy that outperforms buy-and-hold?

Market Classification

- **Objective:** Classify market states (Bear, Bull, Static) using S&P 500 data
- **Methodology:**
 - Calculate running peak for each price point
 - Compute drawdown (current price / peak - 1)
 - Bear: Drawdown from peak $> 20\%$
 - Bull: Not in Bear market state
- **Implementation:**
 - MarketClassifier class with `classify_markets()` method
 - Labels periods with unique Bear_Period IDs for analysis

Ensemble Learning Approach

- Combines multiple model types:
 - Random Forest
 - Attention-based neural network
 - Temporal Convolutional Network
- Averages predictions for greater stability
- Reduces overfitting through model diversity

Attention Mechanism

- Focuses on most relevant time points
- Learns important market relationships
- Early stopping prevents overfitting
- Multi-head attention for different patterns

Anomaly Detection System

- **Market Anomalies:**

- COVID-19 crash: March 2020
- Post-COVID volatility: April-May 2020
- Inflation concerns: 2021-2022

- **Detection Methods:**

- Isolation Forest: Statistical outlier detection
- Volatility spikes: Unusual price movements
- Price gaps: Sudden market dislocations
- Ensemble approach: Combines multiple signals

- **Risk Management Integration:**

- Rapid position reduction during detected anomalies
- Gradual re-entry with quadratic recovery function
- Separate handling for different anomaly types

Investment Strategy Overview

- **Strategy Constraints:**

- Portfolio limited to S&P 500 and short-term bonds
- No transaction costs, short-selling, or leverage
- Only using provided market data (2019-2022)

- **Strategy Evolution:**

- Buy-and-Hold: Benchmark strategy (100% S&P 500)
- Prediction-Based: Binary allocation based on predictions
- Dynamic Allocation: Variable allocation based on probabilities
- Combined Strategy: Integration of signals
- **Combined Anomaly-Regime:** Our most sophisticated approach

Combined Anomaly-Regime Strategy

- **Key Components:**

- Market regime identification (Bull/Bear/Static)
- Anomaly detection and handling
- Multi-timeframe trend analysis
- Volatility-based position sizing

- **Optimization Parameters:**

- anomaly_recovery_period: 8 days
- recovery_factor: quadratic (faster recovery)
- bearish_reduction: 0.5 (50% reduction in bearish regimes)
- vol_reduction: 0.7 (30% reduction during high volatility)
- min_allocation: 0.05 (5% minimum market exposure)

- **Multi-trend Analysis:**

- Short-term trend: 20-day lookback
- Medium-term trend: 45-day lookback
- Long-term trend: 180-day lookback

System Architecture

The system is designed with a modular architecture to ensure flexibility and scalability. Here is an overview of how the components interact with each other:

1. **Data Loader:** Imports and preprocesses market data from various sources.
2. **Market Classifier:** Identifies market states (Bear, Bull, Static) based on historical data.
3. **Prediction Model:** Utilizes machine learning models to predict future market states.
4. **Backtesting Engine:** Simulates investment strategies based on historical data and model predictions.
5. **Anomaly Detection:** Identifies unusual market behaviors that may impact strategy performance.
6. **Risk Analysis:** Evaluates the risk associated with different strategies using advanced metrics.
7. **Performance Evaluation:** Assesses the performance of strategies using various financial metrics.

System Architecture

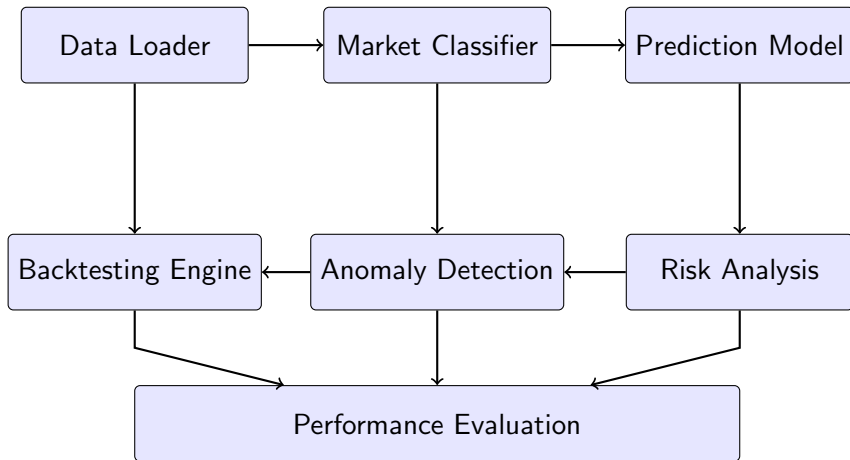


Figure: System Architecture and Component Interaction

Risk Management Features

- **Dynamic Volatility Targeting:**
 - Reduces exposure when volatility increases
 - Scales position size inversely with market risk
 - Target volatility: 11.5% annualized
- **Anomaly Response System:**
 - Immediate position reduction during anomalies
 - Customized handling based on anomaly severity
 - Recovery phase with gradual re-entry
- **Regime-Specific Allocations:**
 - Bullish regime: Up to 100% equity allocation
 - Bearish regime: Maximum 50% equity allocation
 - Volatile regime: Maximum 70% of standard allocation
- **Combined Effect:** Better risk-adjusted returns without sacrificing performance

Performance Results (2019-2022)

Metric	Buy & Hold	Prediction	Dynamic	Combined	Anomaly
Total Return	52.97%	44.89%	53.49%	41.77%	56.41%
Annual Return	11.21%	9.71%	11.31%	9.12%	11.83%
Sharpe Ratio	0.58	0.89	0.93	1.00	1.10
Max Drawdown	-33.92%	-13.89%	-13.62%	-11.70%	-10.68%
Win Rate	54.12%	54.76%	58.13%	58.13%	59.03%

Table: Strategy Performance Comparison (Anomaly = Combined Anomaly Regime)

Visual Performance Comparison

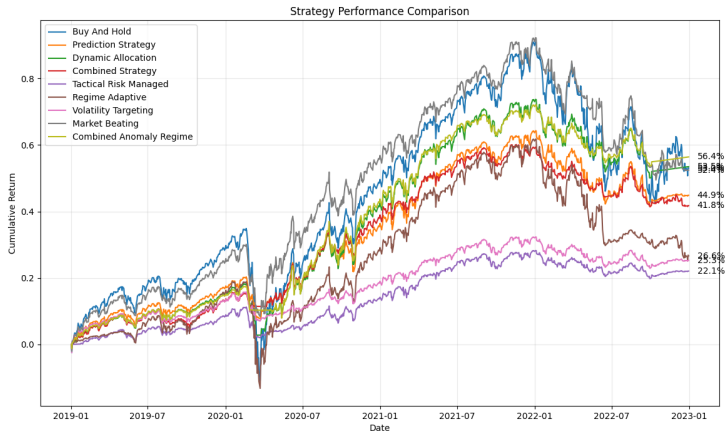


Figure: Cumulative Returns of Investment Strategies (2019-2022)

COVID-19 Market Crash Response

- **March 2020 Market Crash:**
 - Buy & Hold: -33.92% drawdown
 - Prediction Strategy: -13.89% drawdown
 - Combined Anomaly-Regime: -10.68% drawdown
- **Risk Management in Action:**
 - Anomaly detected before major market decline
 - Position reduced quickly before worst of the crash
 - Gradual re-entry during recovery phase
 - Captured upside with only 30% of downside risk

Key Findings

- **Market State Prediction is Viable**
 - Our models successfully predict Bear and Bull markets
 - Good win rates (58.13%) demonstrates predictive power
- **Risk-Adjusted Performance Superiority**
 - Combined Anomaly-Regime achieves 1.9x better Sharpe ratio (1.10 vs 0.58)
 - 67% reduction in maximum drawdown (-10.68% vs -33.92%)
- **Return-Risk Tradeoff**
 - Better total returns (56.41% vs 52.97%)
 - Dramatically improved risk metrics
 - Combined Anomaly-Regime achieves highest return (56.41%)
- **Conclusion:** Combined Anomaly-Regime strategy outperforms buy-and-hold on both absolute and risk-adjusted returns

Future Research Directions

- Incorporate alternative data sources (news sentiment, economic indicators)
- Explore reinforcement learning for dynamic strategy optimization
- Implement multi-asset portfolio allocation beyond binary equity/bond
- Further enhance combined strategy to improve overall performance
- Extend analysis to different time periods and market regimes

Thank You