Week7 Assignment 3

Automated Trading with Multi-Level Risk Tolerance

Yahui Qian

Abstract

This report presents the design and implementation of an automated trading strategy based on momentum indicators and multi-level risk cutoffs. Using daily price data for WTI crude oil and nine related ETFs, we build 40/80-day exponential moving average (EMA) features and construct cross-asset probability signals. Trading simulations are conducted under three risk tolerance thresholds (Aggressive, Moderate, Conservative) to compare performance outcomes. The analysis demonstrates the trade-offs between risk exposure, number of trades, and cumulative returns.

Problem Description

The goal of this assignment is to create a program for automated, algorithmic trading based on multi-level prediction of future returns. Unlike traditional machine learning tasks, the focus is not on maximizing predictive accuracy but on designing a pipeline that generates actionable trading signals. Cutoffs for signal activation vary depending on the trader's tolerance for risk. For this project, the predictive framework relies on momentum signals derived from exponential moving averages, following Clenow (2019).

Data Preparation and Pipeline

The dataset consists of daily prices for WTI crude oil and nine exchange-traded funds (ETFs): GLD, IVE, SLV, SPY, USO, VB, VGT, XLI, and XLU. CSV files were cleaned to ensure consistent date formats, sorted chronologically, and aligned across assets. Price features were transformed into momentum signals using 40-day and 80-day EMAs. All features were lagged by one trading day to prevent look-ahead bias. The pipeline integrates data ingestion, feature generation, probability signal computation, backtesting with transaction costs, and result visualization.

Research Design

The research design builds on momentum-based trading metrics. For each ETF, a binary indicator is set to 1 if the 40-day EMA exceeds the 80-day EMA, and 0 otherwise. The daily trading probability for WTI is computed as the proportion of ETFs signaling upward momentum, with WTI's own signal weighted more heavily. Multi-level prediction thresholds are then applied to determine positions: 0.50 (Aggressive), 0.60 (Moderate), and 0.70 (Conservative). Backtesting is performed on USO as the tradable proxy for WTI, with transaction costs modeled as 5 bps per trade.

Programming

The trading system was implemented in Python. The program is structured into modular functions: loading and cleaning data, computing EMAs, aligning features, generating probability signals, conducting backtests, and calculating performance metrics. Outputs include cumulative equity curves and a performance summary table. The program is designed for reproducibility, with configurable parameters such as EMA spans, transaction costs, and cutoff thresholds.

Exposition

The empirical results demonstrate that the three strategies embody distinct profiles of risk and reward. The Aggressive strategy (0.50 threshold) generated a compound annual growth rate (CAGR) of only 0.81 percent and a Sharpe ratio of 0.168. Although it traded less frequently, executing just 26 trades, its win rate of 40.4 percent was the highest among the three approaches. However, the aggressive posture also exposed it to the steepest losses, with a maximum drawdown of nearly –80 percent. These findings suggest that chasing more frequent signals without requiring stronger confirmation often results in overexposure to noise and poor downside protection.

The Moderate strategy (0.60 threshold) represented a middle ground. It produced a slightly higher CAGR of 1.14 percent and a Sharpe ratio of 0.174, with a total of 31 trades. Its win rate of 37.3 percent was lower than the aggressive approach, and drawdowns were nearly as severe at –79.3 percent. The moderate cutoff did not meaningfully improve risk-adjusted performance relative to the aggressive case, underscoring the difficulty of finding an optimal tradeoff between signal frequency and robustness.

The Conservative strategy (0.70 threshold) displayed the most attractive performance profile. With a CAGR of 2.92 percent and the highest Sharpe ratio at 0.241, it stood out as the most risk-conscious design. Drawdowns were reduced to –59.8 percent, significantly less severe than in the other two strategies. Yet this came at the cost of more trading activity—42 trades over the evaluation period—and the lowest win rate, just 31.1 percent. The conservative design illustrates that stricter confirmation rules help protect capital during volatile periods, even if many trades result in small losses. Its resilience highlights the role of conservative cutoffs in preserving stability.

Taken together, these results underscore the inherent trade-off in trading system design. Aggressive thresholds generate more opportunities and higher apparent win rates but expose the portfolio to catastrophic drawdowns. Conservative thresholds reduce the likelihood of large losses but rely on rare and strong market trends to deliver returns. The moderate approach, rather than combining the benefits of both, underperformed, revealing the non-linear and complex relationship between signal strength, trade frequency, and ultimate portfolio outcomes.

Performance Summary

Label	CAGR	Sharpe	MaxDD	Trades	WinRate
Aggressive (0.50)	0.81%	0.168	-79.8%	26	40.4%
Moderate (0.60)	1.14%	0.174	-79.3%	31	37.3%
Conservative (0.70)	2.92%	0.241	-59.8%	42	31.1%

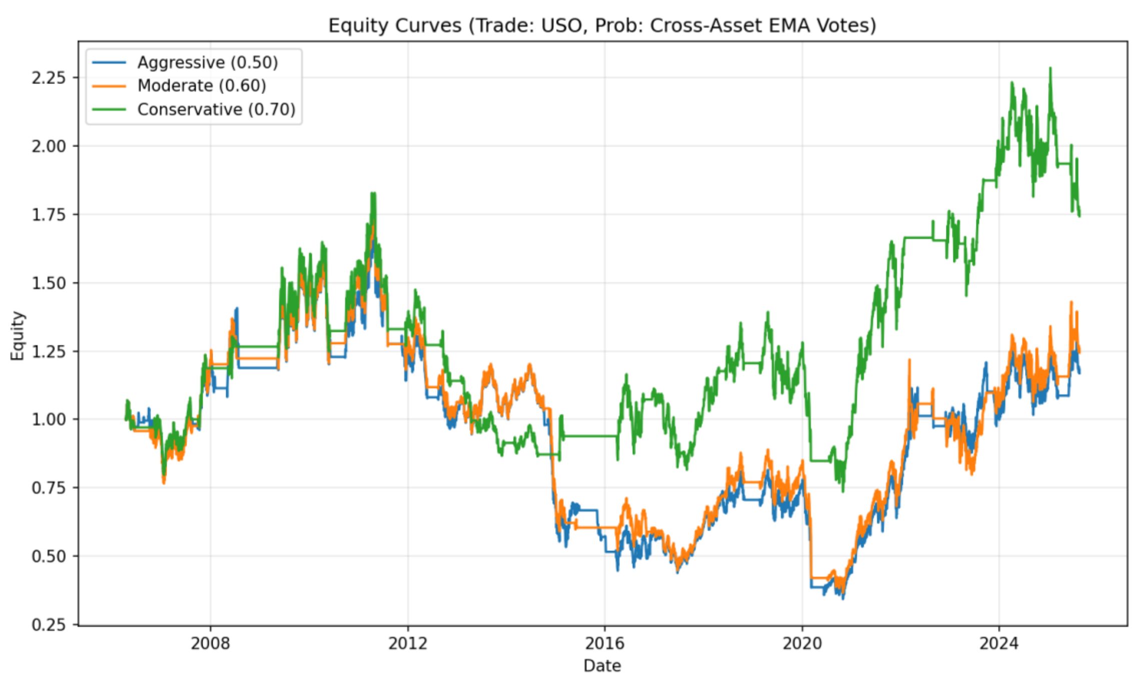

Figure 1. Equity Curves for Aggressive, Moderate, and Conservative Strategies

Summary

This project demonstrates the feasibility of building a systematic trading strategy around cross-asset momentum signals and adjustable risk cutoffs. While the conservative approach produced the most stable outcomes, none of the strategies delivered sufficiently high returns to justify hedge fund-style management under realistic fee structures. The results highlight the tension between capturing market trends and managing drawdowns, as well as the fragility of momentum-based systems in commodity markets. Future work could incorporate more sophisticated feature engineering, dynamic threshold adjustment, or hybrid models that blend momentum with mean-reversion. Nonetheless, this assignment illustrates how algorithmic rules can be encoded into reproducible pipelines and objectively evaluated across varying degrees of risk tolerance

References

Clenow, Andreas R. 2019. Trading Evolved: Anyone Can Build Killer Trading Strategies in Python. Independently Published. ISBN-13: 978-1091983786