AI Crypto Hedge Fund

INTEGRATING CRYPTO AND AI-DRIVEN TRADING

The Hedge Fund Model
A Multi-Model Approach

Goal – build and compare strategies of increasing sofistication

1. The Baseline – SMA Crossover

- simple, rule-based strategy that reacts to past price trends by tracking moving averages.

2. The Enhancement – ARIMA Model

- known statistical model that forecasts the next price point based on recent historical data.

3. The Advanced Model – LightGBM AI Agent

- machine learning model that predicts future price direction by learning complex patterns from multiple features (RSI, MACD, Volatility).

“ SMA, ARIMA and AI outperform basic Buy-and-Hold model, providing predictive, risk-adjusted and data-driven approach “

	Buy and Hold	SMA	ARIMA	AI (LightGBM)
ROI (%)	36.75	16.41	21.40	**40.57**
Volatility (%)	**45.98**	**31.08**	**31.39**	36.54

Future Enhancements

Model Sofistication

1. Specialized Models

Train a Model per Asset

Move beyond a single, generalized model by training a unique AI Agent for each cryptocurrency. This allows the model to learn the specific patterns and dynamics of each asset.

2. Ensemble Methods

Combine Models

Instead of relying on one prediction, we can combine the signals from multiple models (e.g., ARIMA and LightGBM). This creates a more robust signal that is less prone to the errors of a single approach.

3. Advanced Architectures

Explore Deep Learning

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Key Impact: More robust, accurate, reliable signal generation

Risk Management
Active Risk Control

Quantifying Risk

1. Volatility

Measures the intensity of price swings. A lower value means a smoother journey.

2. Max Drawdown

The worst-case loss from a peak to a trough. A smaller value shows better capital protection.

Controlling Risk

3. The ATR Volatility Filter

Our system uses the Average True Range (ATR) to measure real-time volatility. If the market becomes too "choppy" (e.g., ATR > 4% of the price), the strategy is programmed to stay in cash, avoiding potential losses.

	Buy and Hold	Static Portfolio	Dynamic AI Portfolio
Max Drawdown (%)	**-37.20**	**-30.62**	**-22.69**
Volatility (%)	**45.98**	47.38	**35.88**

Future Enhancements

Advanced Risk Control

1. Position Risk

Dynamic Stop-Loss

Implement a dynamic stop-loss for each trade based on real-time volatility (e.g., a 1.5x ATR trailing stop). This actively protects profits and further limits the downside of individual positions.

2. Portfolio Risk

Risk-Based Position Sizing

Adjust position sizes based on risk. For example, allocate less capital to assets with higher recent volatility, ensuring no single asset can overly impact the portfolio's performance.

3. Fund Risk

Tail Risk Monitoring

Introduce fund-level metrics like **Value-at-Risk (VaR)** and **Conditional Value-at-Risk (CVaR)**. These measures estimate the maximum potential loss, helping to manage and prevent catastrophic "tail risk" events.

Key Impact: More resilient, institution-quality trading systems

Portfolio Management

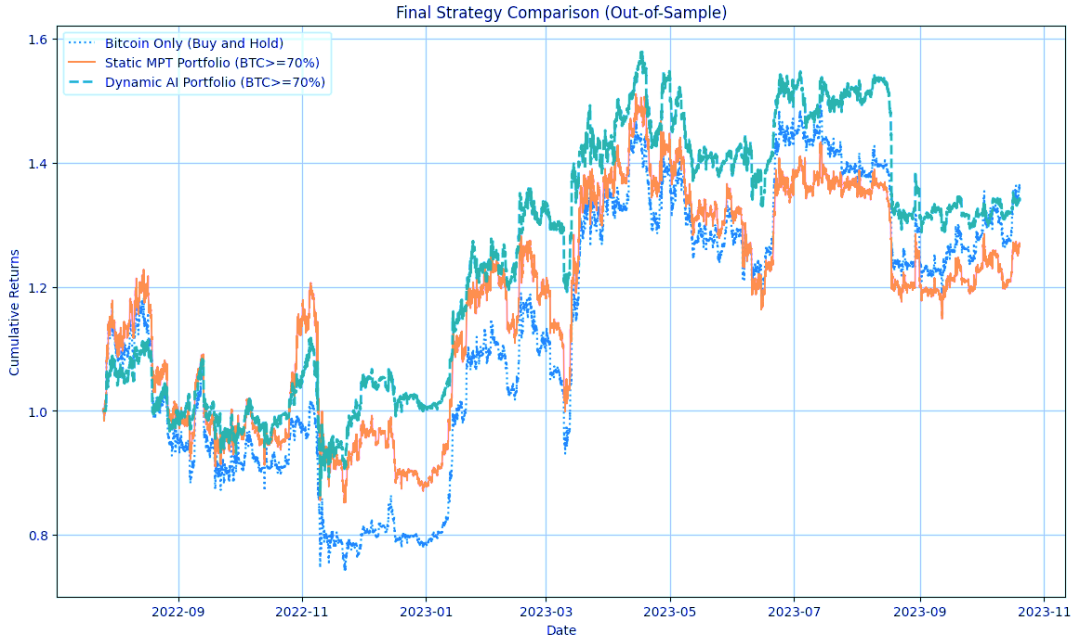
From static to dynamic

1. Static Baseline Portfolio

We first used **Modern Portfolio Theory (MPT)** to find the optimal **static** (fixed-weight) allocation based on historical training data. A Monte Carlo simulation identified the portfolio with the highest Sharpe Ratio, subject to a >=70% Bitcoin constraint.

2. Dynamic AI Portfolio

We then enhanced this portfolio by using our **AI Agent** as a **dynamic** overlay on the static MPT weights. The AI's hourly buy/sell signals act as a tactical "on/off" switch for each asset, actively managing the portfolio's exposure.



Future Enhancements
Advanced Portfolio Management

1. Strategic Rebalancing

Periodic MPT Re-Optimization

Our current "base" weights are calculated once on the training data. A more adaptive approach is to re-run the MPT optimization periodically (e.g., every month). This would adjust the strategic, long-term allocation to reflect the most recent market returns and risk profiles.

2. Tactical Rebalancing

Signal-Based Weighting

Move beyond a simple on/off signal. The AI model's output (a probability from 0.0 to 1.0) can be used to directly influence the portfolio weights. A high-confidence "buy" signal could increase an asset's allocation, while a low-confidence signal could reduce it.

3. Add Sentiment Analysis

News, Hype and Fear

Add a score based on the general mood (positive, negative, neutral) from platforms like X/Telegram, perform analysis of headlines of major financial newspapers

Key Impact: Adjust long-term outlook and short-term positioning

System Architecture
As-Is Status

1. Data Preparation

Loads crypto_all.csv, cleans the data (handles duplicates, missing values), sorts it chronologically, and splits it into an 80% Training Set and a 20% Test Set.

2. AI Model Training

Uses the Training Set (BTC data) to perform feature engineering (RSI, MACD, etc.) and train the LightGBM model to predict future price direction. The output is a Trained Model.

3. MPT Optimization

Uses the Training Set (multi-asset data) to run a Monte Carlo simulation and find the optimal static portfolio weights based on the highest Sharpe Ratio, subject to any constraints (e.g., BTC >= 70%). The output is the Optimal Weights.

4. Strategy Backtesting

Uses the Test Set along with the Trained Model and Optimal Weights from the previous steps. It simulates the performance of all strategies (Bitcoin-Only, Static MPT, Dynamic AI Portfolio).

5. Analytics & Visualization

Takes the backtest results and calculates all key performance metrics (ROI, Sharpe Ratio, Volatility, Max Drawdown). It generates the final comparison tables and charts (Equity Curves, Radar Chart).

Future Enhancements

Production-Ready Architecture

1. Live Data & Execution

API Integration

Replace the static CSV file with a real-time data feed by connecting to exchange APIs (e.g., **Binance, Hyperliquid**). Implement an execution module to automatically place orders based on the AI's signals.

2. Robust Data Management

Dedicated Database

Incorporate a database (e.g., **PostgreSQL**) to store all historical data, model signals, executed trades, and performance metrics. This ensures data integrity and allows for more advanced, long-term analysis.

3. Real-Time Monitoring

Live Dashboard & Control

Develop a monitoring dashboard or a **Telegram** bot to provide real-time updates on the fund's performance and system health. This would also allow for manual overrides or a "kill switch" for safety.

Key Impact: Fully-fledged, automated, user-friendly systems

Summary of Key Achievements

Done so far

1. Proven Predictive Power

Successfully demonstrated that predictive models (ARIMA and our AI Agent) deliver a significant performance edge over both passive buy-and-hold and simple rule-based (SMA) strategies in out-of-sample testing.

2. End-to-End Framework

Develop a monitoring dashboard or a **Telegram** bot to provide real-time updates on the fund's performance and system health. This would also allow for manual overrides or a "kill switch" for safety.

3. Dynamic Portfolio Outperformance

The final **Dynamic AI Portfolio** was the best overall performer, achieving the highest Sharpe Ratio and the lowest Max Drawdown. This proves the value of combining strategic allocation (MPT) with a tactical, AI-driven overlay.

Conclusion & Project Roadmap

To Be Done

1. Refine Strategy

Improve Core Trading Logic

- Train a specialized AI model for each asset
- Implement advanced risk controls like dynamic stop-losses and risk-based position sizing.

2. Transition to Production

Build a Live Automated System

- Integrate live data exchange via API
- Develop an automated trade execution module
- Build a database and dashboard for real-time monitoring

3. Fund Expansion

Scale the Project into a diversified, multi-strat Fund

- Research and deploy new, uncorrelated trading strategies (e.g., market-neutral arbitrage, options strategies).Develop an automated trade execution module
- Apply the quantitative framework to other markets, such as equities, forex, or commodities.