Meet The Team

Risk Management for Tech Index Portfolio

Volatility-Targeted Delta and Gamma Hedging for a Tech Index Portfolio

MATH 583: Final Presentation

Nzarama Kouadio
Data Science Student
Duke MIDS 2026

Si Min Loo (Lucy)
Data Science Student
Duke MIDS 2026

Ramil Mammadov
Data Science Student
Duke MIDS 2026

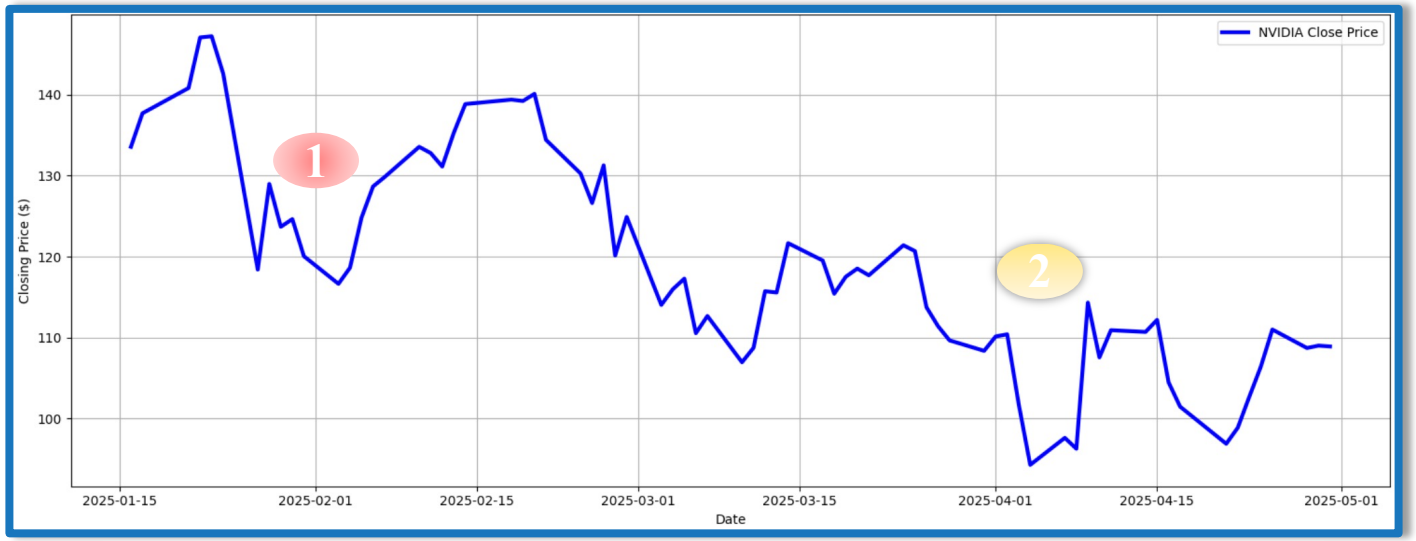
Cynthia Zhou
Data Science Student
Duke MIDS 2026

Agenda

1. **Project Overview**
2. **Data Source and Key Features**
3. **Predicting Market Volatility**
4. **Hedging Strategy**
5. **Back-testing, Strategy Evaluation and Limitations**

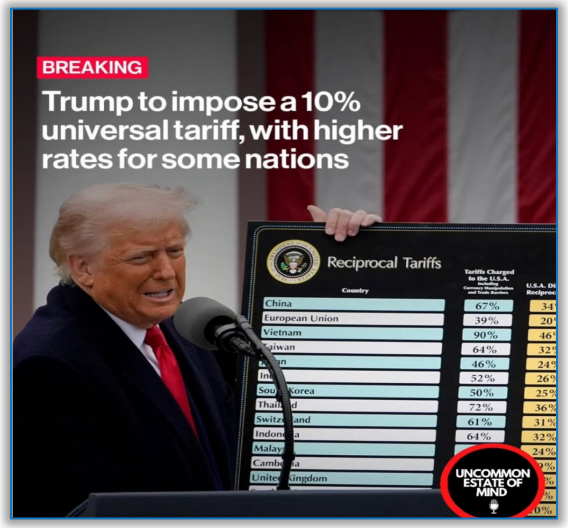
Why Volatility Hedging Matters Today

NVIDIA Stock Price Drop Since January 2025



NVDIA SUFFERS RECORD **$600 BILLION LOSS**

TRUMP IMPOSES **145% TARRIF** RATE ON CHINA



Project Overview: Tech Portfolios Need Smarter Risk Control

Objective

Maintain a **20%** volatility target and use delta and to actively manage risk and stabilize our QQQ portfolio **($10 Million)** in volatile markets

Our Strategy

Risk Modeling Approach:

Use GARCH and XG-Boost to forecast volatility

Risk Management Methodology:

Hedge with QQQ options using volatility targeting, delta neutral strategies

Business Impact

- ✓ Enhances portfolio resilience
- ✓ Stabilizes volatility near target
- ✓ Reduces losses from price swings
- ✓ Improves risk-adjusted returns

Data Overview: Source, Key Variables, & Structure

yahoo!finance

OptionMetrics wrds WHARTON RESEARCH DATA SERVICES
The Global Standard for Business Research

QQQ ETF Data

- **Date**: Trading date
- **Return**: Daily return of QQQ
- **Realized Volatility**: 21-day rolling annualized volatility
- **Volume**: Trading volume

Macro Market Risk Indicators

- **VIX:** S&P 500 implied volatility index
- **VXN:** Nasdaq 100 implied volatility index
- **Fed Rate:** Proxy for the Fed Funds Rate using IRX
- **RSI 14:** 14-day Relative Strength Index

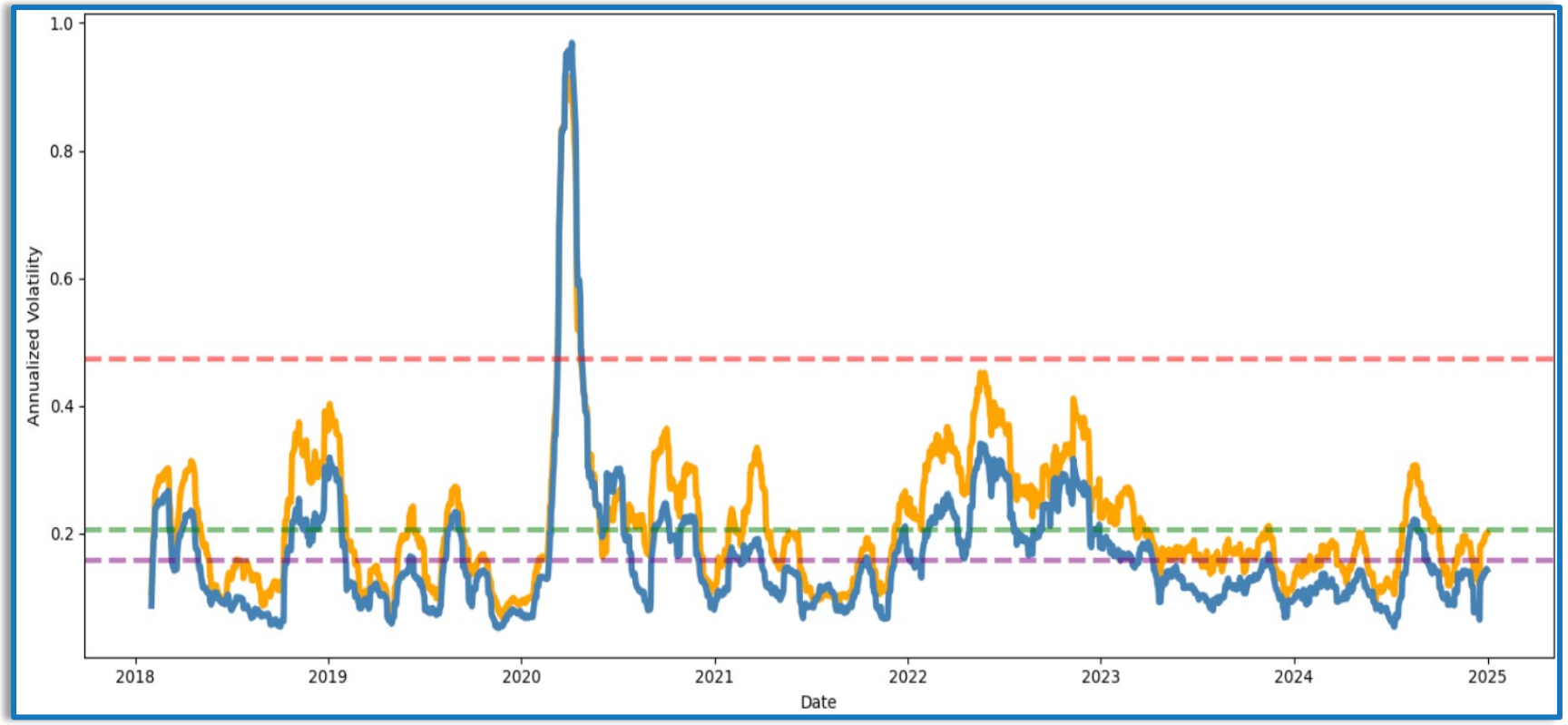
QQQ Option Data

- Call Options
- Put Options

  Strike price, delta, gamma, implied volatility

Data Overview: Volatility Landscape of QQQ

QQQ vs S&P 500 Annualized Realized Volatility (21-Day Rolling)



- QQQ Realized Volatility
- S&P 500 Realized Volatility
- 1% Daily = 16% Annual
- 1.3% Daily = 21% Annual
- 3% Daily = 48% Annual

Volatility Type	Nature	Risk
Normal (-/+ 1.3%)	Frequent Moves	Volatility Drag
Sudden (-/+ 3-5%)	Extreme Moves	Large Fall

Modeling: Predicting QQQ Volatility Using GARCH and XG-Boost

- Compare GARCH(1,1) vs XG-Boost for predicting QQQ volatility
- Support delta hedging & volatility targeting (**keep volatility < 20%**)
- Focus is on real-world applicability, not which model is "better" in general

One Step-Ahead Forecasting Framework

- Mimics real trading: forecast tomorrow's risk
- Allows daily rolling evaluation
- No data leakage from the future
- Ensures fair comparison across models

1 GARCH (1, 1) Statistical Model

Rolling Expanding Window (start date to previous predicted day)

- Stable parameter estimation
- Leverages long-term volatility structure

2 XG Boost (Machine Learning Model)

Rolling Fixed Window (Rolling the most recent 3 years)

- Avoids overfitting
- Adapts to regime changes
- Uses market features (VIX, VXN, ...)

Forecasting QQQ Volatility: Using GARCH(1,1) Model

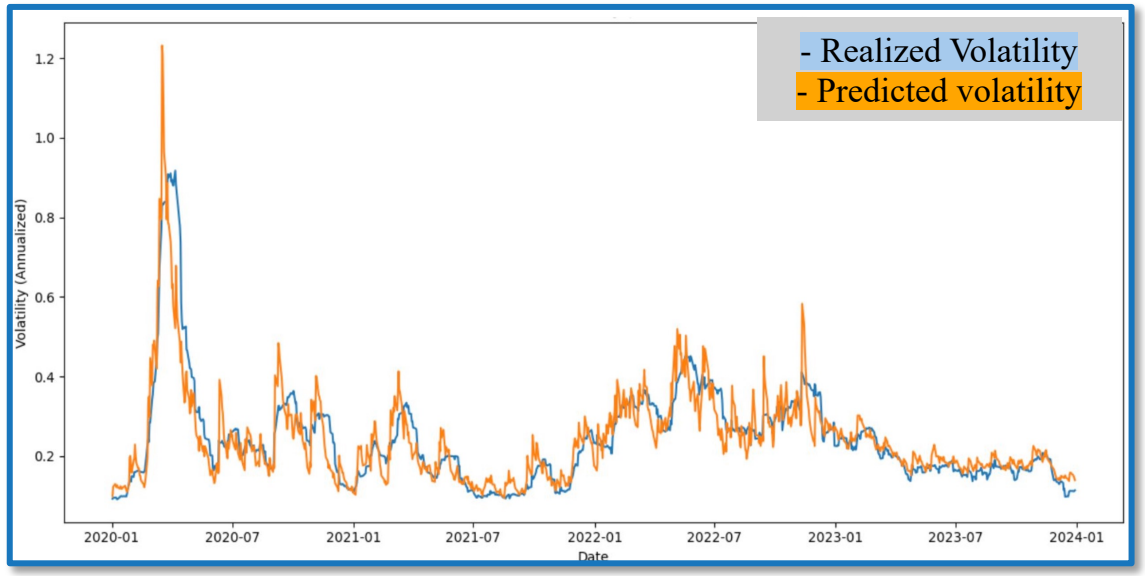
Testing Base GARCH Assumptions

1. **ADF test for stationarity:** p-value: 3.79e-29 < 0.05
2. **Testing for ARCH Effects:** p-value: 2.43e-144 < 0.05

	Fixed	Expanding	Comparison
R square	0.791	0.835	↑ + 9%
RMSE	0.058	0.051	↓ - 7%
MAE	0.038	0.032	↓ - 6%

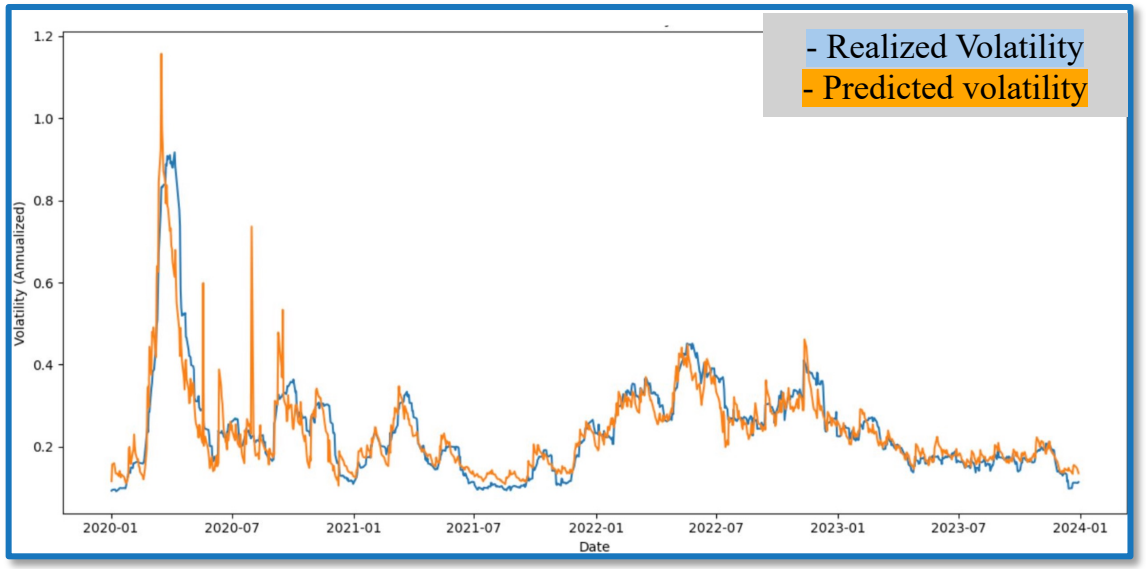
GARCH(1,1): **Rolling Fixed-Window** [Robustness Test]

Realized vs Predicted Volatility Over Time



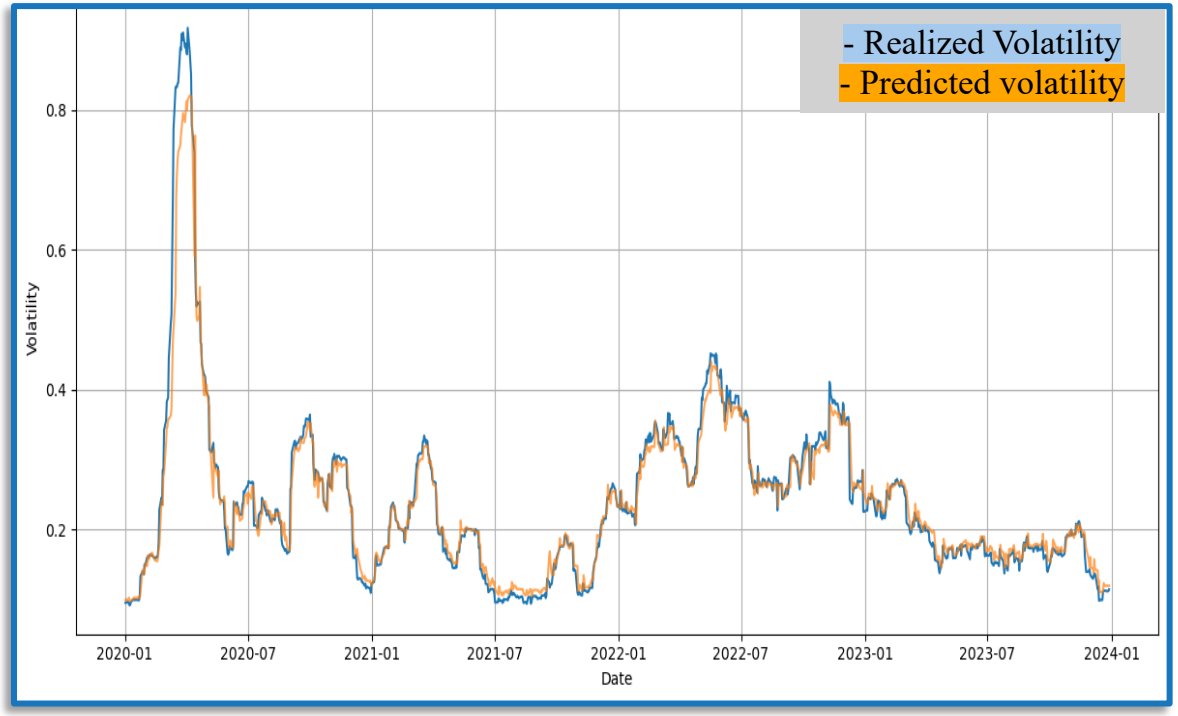
GARCH(1,1): **Rolling Expanding-Window**

Realized vs Predicted Volatility Over Time

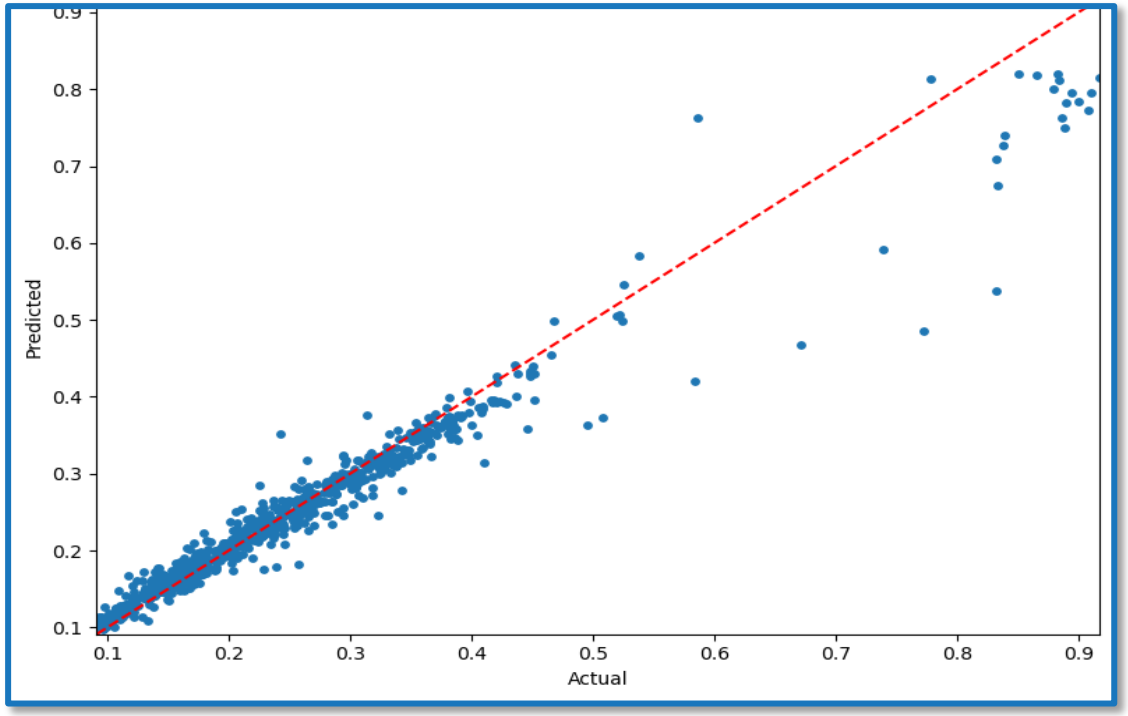


Forecasting QQQ Volatility: Using XG-Boost Model

Time Series of Actual vs Predicted Volatility



Prediction Fit: Actual vs Predicted

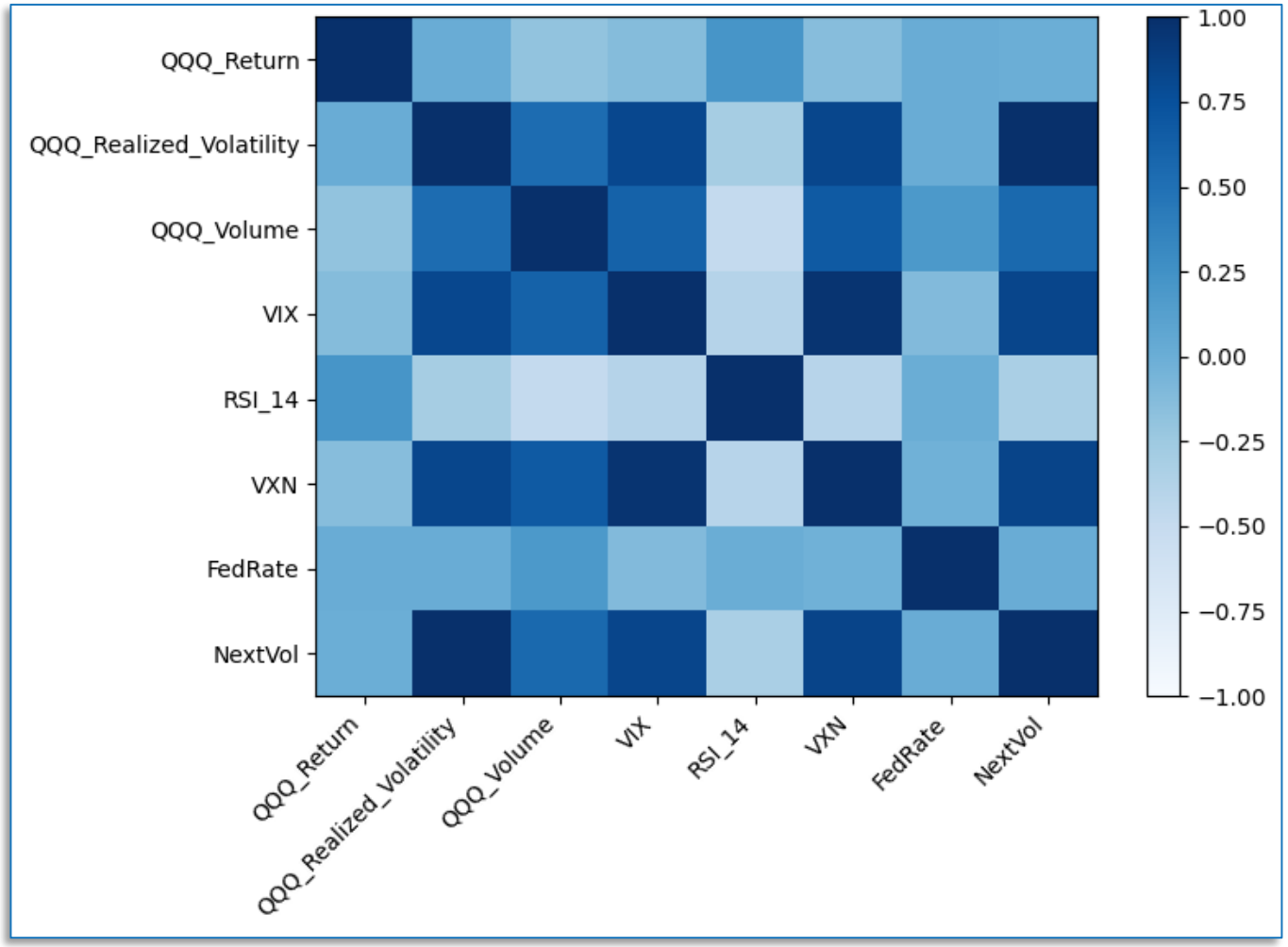


Performance Metrics

- R square: **0.95**
- RMSE: **0.028**
- MAE: **0.01**

Feature Analysis through Correlation Matrix for XG-Boost

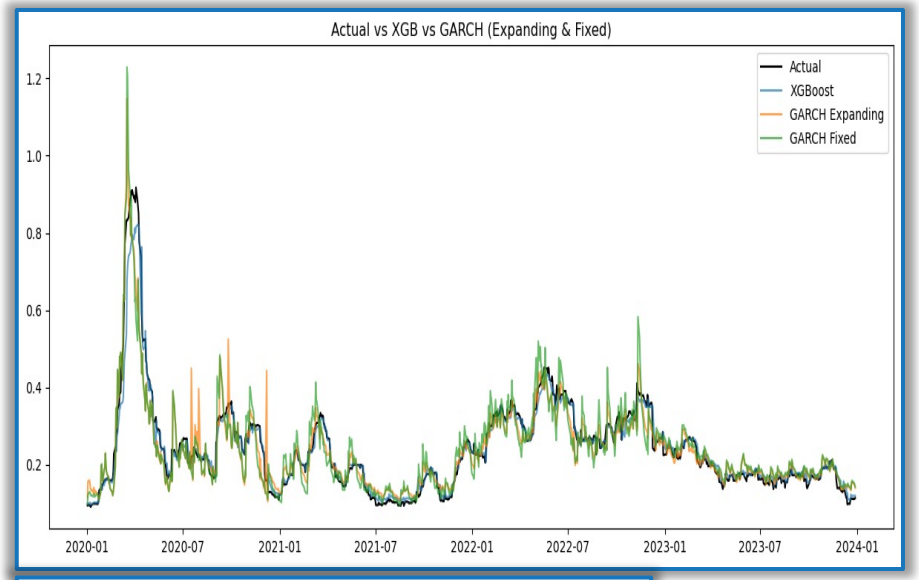
Feature Correlations Behind XG-Boost's Strong Forecasts

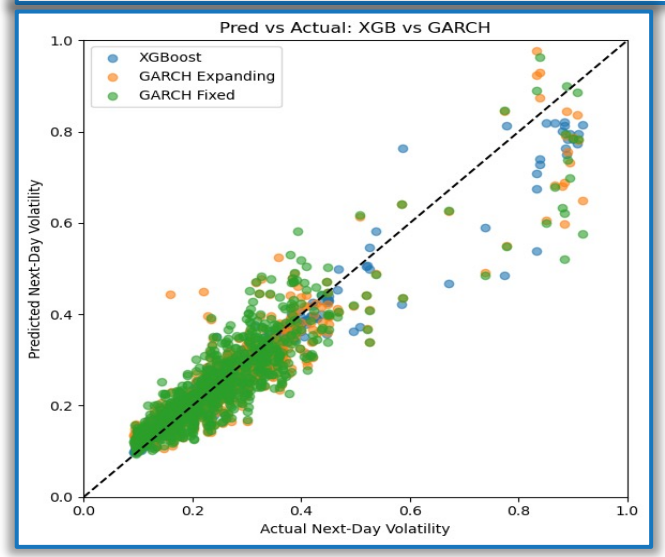


Strong Feature Correlation with Next-Day Volatility

- QQQ Realized Volatility (~ +0.9)
- VXN, VIX (~ +0.7 – 0.8)
- QQQ Volume (~ +0.25 - 0.5)

Comparison: XG-boost the Leading Model based on Performance Metrics

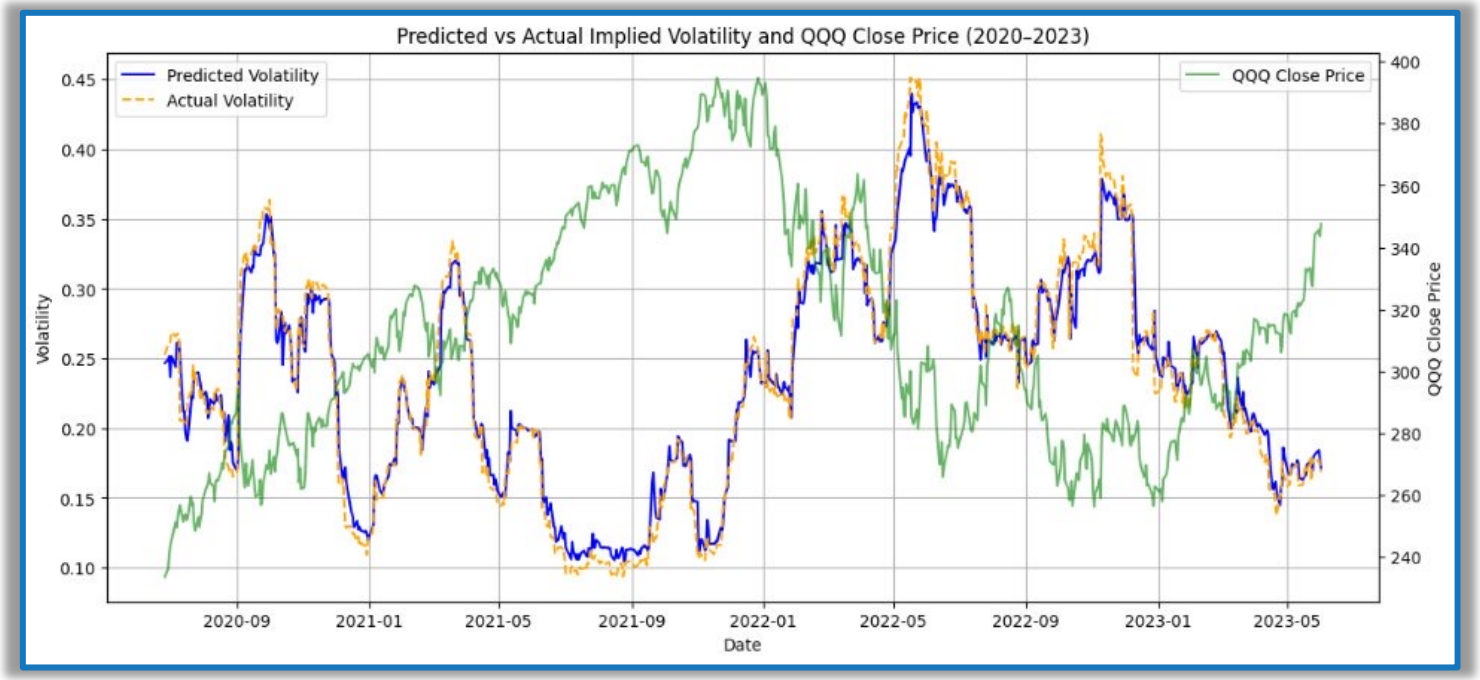




	XG-Boost	GARCH Model	GARCH Model
	• Rolling Fixed • One Step Ahead	• Rolling Expanding • One Step Ahead	• Rolling Fixed • One Step Ahead
R Square	**0.952**	**0.835**	**0.791**
RMSE	**0.028**	**0.032**	**0.038**
MAE	**0.01**	**0.051**	**0.058**

Hedging Strategy Methodology: Regime Specific Hedging

Predicted vs Actual Implied Volatility and QQQ Close Price (2020-2023)



Volatility and QQQ show an inverse relationship, guiding our regime-specific hedging strategy

Why Use Regimes

- Market volatility impacts risk
- Based on predicted volatility levels
- Based on historical market behavior and practical trading considerations

3 Regime Classifications

- **Low Volatility**: Predicted < 0.20 → Calm, stable markets
- **Moderate Volatility**: 0.20–0.35 → Some uncertainty, balanced protection needed
- **High Volatility**: > 0.35 → Stress/crisis periods, strong protection required.

Option Hedging Strategy at each Volatility Regime

	Strategy	Methods	Benefits
Low: < 20%	Light Collar Strategy	Buying 5% OTM & selling a 5% OTM call	Affordable protection and captures gains in stable markets
Moderate: 25-35%	Protective Put Spread	Buying 5% OTM put & selling a deeper 15% OTM put	Covers mid-sized losses with lower cost than buying just a put
High: 35% >	Protective Put	Purchasing a standalone put roughly 3-5% OTM	Strong protection during big crashes, ensures portfolio has a set floor

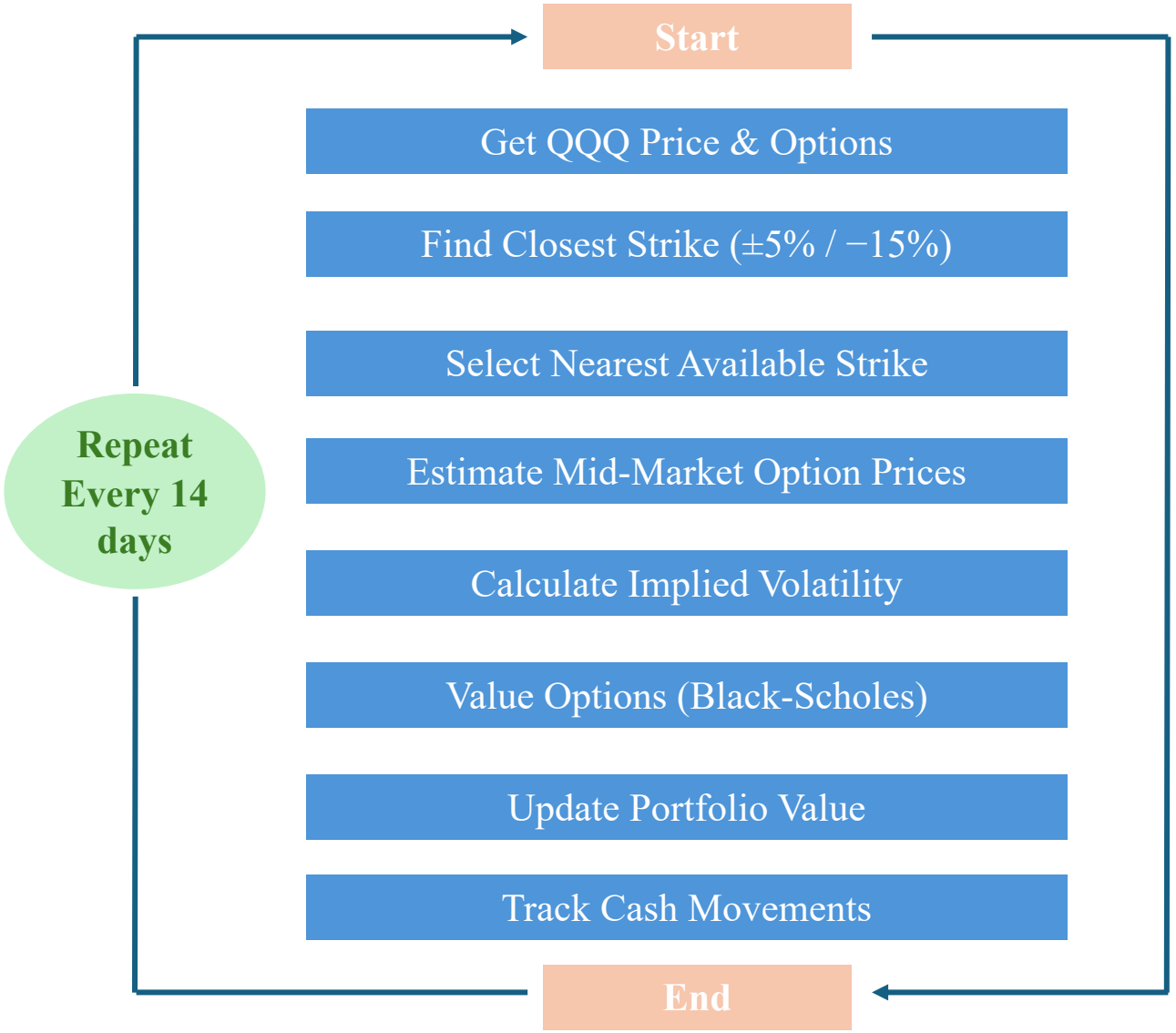
Strategy Implementation

Overall Strategy Design

- Rebalanced portfolio every 14 days
- Used XG-Boost to predict next-day volatility
- Apply matching options strategy based on predicted regime

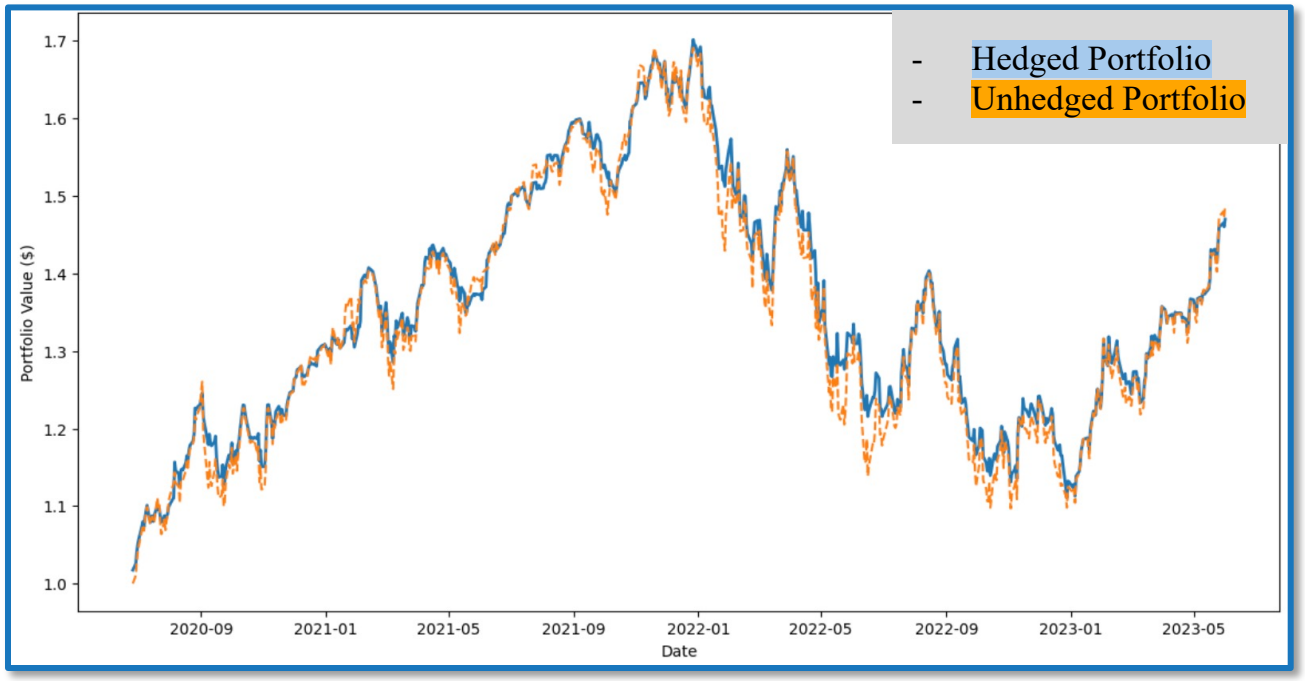
Starting Parameters

- **Initial Portfolio Value**: **$10 million** invested in QQQ ETF shares.
- **Instruments Set**: Long and Short Options Positions



Back-testing Results and Metrics

Comparison of QQQ Portfolio Value: Hedged vs Unhedged (2020-2023)



	Unhedged	Hedged	Comparison
Annualized Volatility	25%	19%	**-24%**
Sharpe Ratio	0.6	0.7	**+ 17%**
Cumulative Return	49%	44%	**- 10%**
Maximum Drawdown	-35.1%	-34.7%	**+ 1.1%**

Successfully reduced volatility and still deliver strong long-term performance

Limitations and Future Work

Limitations	Opportunities
Absence of Transaction Costs and Liquidity Constraints	Include Realistic Slippage and Option Spreads
Constant Implied Volatility Assumption	Integrate Dynamic Volatility Estimation Methods
Narrow Hedging Instrument Set and Simplified Contract Behavior	Include Multi-Asset Hedging or Cross Hedging

THANK YOU FOR YOUR ATTENTION!

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Q&A