



LAKE FOREST
COLLEGE



FIN 485 – Quantitative Finance

Volatility Arbitrage Strategy Presentation

12/13/2024

Authored by:

*Ethan Hammontree
Georgios Giannopoulos
Peter Liphardt
Ian Villardi
Greta Gerard*

*Luca Vulpescu
Niko Gkoutziamanis
Zaina Quadri
Jake Kostoryz*

Table of Contents



01	02	03	04	05
Executive Summary	Literature Review	Investment Philosophy	Investment Strategy	Alpha Model
06	07	08	09	10
Data Used	Portfolio Optimization	Risk Management	Back-test Analysis	Conclusion

Executive Summary

- **Objective:** Utilize a volatility arbitrage strategy to exploit price inefficiencies between implied volatility (IV) and historical volatility (HV)
- **Indicators:** Employ contrarian Bollinger Bands, RSI, and trend indicators for mean reversion opportunities
- **Asset Selection:** Focus on 100 large-cap stocks and three major cryptocurrencies (Bitcoin, Ethereum, Solana)
- **Risk Management:** Implement stop-loss orders, strategic exit points, and portfolio leverage controls
- **Technical Implementation:** Continuous updates, custom indicators in *OnData* method, trade logic and risk management in *AssetArbitrageStrategy* class

- **Key Results:**
- Net Return (Q1 2024): 8.14% (Annualized: 36.38%).
- Sortino Ratio: 2.09.
- Sharpe Ratio: 2.55.
- Beta: 0.775.
- Maximum Drawdown: 7.3%.

- **Areas for Improvement:**
- High Turnover: 47.12%, leading to substantial transaction costs
- Profit-Loss Ratio: 0.43, indicating losses exceeded average profits



Goyal & Saretto (2009):

- Constructed long/short straddle portfolios based on IV-HV gaps.
- Found significant excess returns, challenging no-arbitrage theory.

Critiques & Limitations:

- Tail Risk: Extreme events can erode profitability (McGee & McGroarty, 2017).
- Variance Risk Premia: Compensates for disaster risk (Bollerslev & Todorov, 2011).
- High bid-ask spreads impact returns (Cao & Han, 2013).
- Returns eroded by market frictions (Christoffersen et al., 2017).

Insights for Research:

- Time Horizon: Weekly options limit tail risks but amplify short-term shocks.
- Liquidity Adjustments: Essential for real-world applicability.
- Hedge Ratios: Improve risk-adjusted returns.

Our strategy operates under the following assumptions:

- 1) Markets are not perfectly efficient
- 2) Short-term price movements create opportunities for traders to profit on mean-reversion tendencies

We utilize indicators such as:

- 1) Contrarian Bollinger Bands
- 2) Relative Strength Index (RSI)
- 3) Other trend-following signals

The algorithm assumes that prices will revert to the mean after significant deviations



Active, long-short and market neutral strategy, with a clear focus on exploiting volatility while efficiently managing risk

1) A Contrarian Bollinger Band

BB's are a Lagging indicator of the Market and of Volatility, so we used the inverse as timing lined up better with trend reversal

Under the assumption that reversion will occur, sell when the asset crosses the top band



2) Relative Strength Index (RSI)

The RSI is a momentum oscillator, relaying when a stock is "overbought" (high RSI) or "underbought" (low RSI)

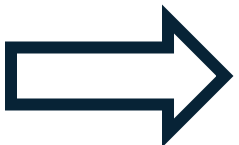
Used as an additional filter to confirm Bollinger bands

RSI < 30 = **Buy** signal
RSI > 70 = **Sell** signal

3) Trend / Historical Volatility

Confirming the historical two standard deviation range of a given asset

Calculating the 50-day SMA as a trend to evaluate price direction



This combination of indicators limits unnecessary background noise while confirming the validity of the movements

Investment Strategy

Coarse Universe Selection

- Top 100 stocks by market capitalization
- Limit to trading at a value over \$20
- Added 3 largest cryptocurrencies by market-cap (BTC, ETC, SOL)

Goal: limit trading volume and minimize transaction fees while sticking to liquid assets with constant historical volatility

- Exit both L & S positions (for gain) when price is above the middle value range of the current 20-day Bollinger band
- Stop losses for L & S positions: sell if 5% loss on L, sell if 3% loss on S
- Long $\leq 5\%$ of portfolio max
- Short $\leq 3\%$ of portfolio max

Without these parameters, we saw substantial losses (realized & unrealized) in our backtests

- No true leverage parameters included (no derivatives)
- No accounting for transaction fees, however limiting volume with our universe selection
- No portfolio weight limitations (80% liquidity max for short trades)

1) Overreaction & Herding behavior

- Overreactions to news and economic shocks drive temporary mis-pricings in either direction, which can be exploited
- Herd mentality amplifies these effects, where the CBB come into play
- (IOSR, 2020)

2) Overconfidence & Attention Spans

- Investors tend to be arrogant and stubborn; the opposite of machines and algorithms
- While (mostly retail) investors continue to ride waves and momentum, our code recognizes trend reversals and will enter and exit positions at the right time as these patterns are predictable
- (Maxum, 2016)



1) Volatility drivers & Economic shocks

- Volatility increases from many events: inflationary pressures, regulation changes, geopolitical events, monetary policy...
- These environments are profit drivers for strategies that trade based on volatility
- (Ruf and Stulmüller, 2017)

2) Highly liquid assets see more corrections

- Common assets amongst retail traders and institutions see higher volume and liquidity, increasing odds of overextensions of trends ("ride the wave")
- If this lasts for too long, opportunities for volatility and mean-reversions are created
- (IOSR, 2020)



Alpha Model

Shortcomings

1. This strategy works best in relatively sideways markets
2. Important losses in bull markets where asset long outruns its 20 SMA and leaves a sell indicator, amplifying losses
3. Liquidity issues can lead to traps in unfavorable positions
4. Possible for Bollinger Bands to miss behavioral market reactions as they are lagging indicators

Our Measures to Avoid Shortcomings:

- Top 100 largest stocks and 3 largest cryptocurrencies, ensuring high liquidity
- Stop-losses
- Contrarian Bollinger Bands mitigate the issue of being lagging indicators



Our strategy combines mean-reversion principles alongside volatility arbitrage to generate positive alpha. Supported by behavioral finance theories and empirical evidence, we leverage technical indicators to exploit market inefficiencies. While persistent trends and transaction costs exist, the strategy's robust design and alignment with macroeconomic conditions make it a compelling approach to achieving superior returns

Data Used

Data Sourcing

Platform: QuantConnect

- Institutional-grade market data.
- Aggregates from top-tier providers:
 1. **Morningstar**
 2. Cryptocurrency data from **Coinbase** and **Binance**.
 3. Equities coverage via **Alpaca** and similar providers.

Equities Dataset:

- 100 **highly liquid stocks**.
- Selection criteria:
 - Average daily dollar volume > **\$10 million**.
 - Share price > **\$5**.

Cryptocurrency Dataset:

- Focused on **BTCUSD**, **ETHUSD**, **SOLUSD**.
- Chosen for high volatility and portfolio diversification potential.

Handled missing values using **Forward-filling** and **interpolation** to ensure continuity.
Extended initialization for accurate technical indicators (**Bollinger Bands**, **RSI**, **SMA**)
Integrated trading constraints like **Transaction fees**, **spreads**, and **slippage**.



Portfolio Optimization

Rules-Based Approach:

- Position sizes determined by predefined risk constraints
- Long and short positions capped and portfolio exposure limited

Contrast with Advanced Techniques:

- Modern Portfolio Theory (MPT): Optimizes trade-off between expected return and risk through diversification
- Risk-Parity Optimization: Allocates capital based on risk contribution of each asset
- Black-Litterman Model: Combines investor views with market equilibrium for optimized weights

Simplified Focus:

- Prioritizes operational efficiency and clarity
- Manages risk at the individual trade level
- Ensures overall portfolio balance and adherence to exposure constraints

Alignment with Strategy:

- Emphasizes volatility arbitrage and mean-reversion signals
- Simplifies risk management while incorporating key elements of advanced techniques

Existing Risk Management:

•Position Sizing:

- Long trades: 5% of portfolio value
- Short trades: 3% of portfolio value

•Stop-Loss Orders:

- Long trades: Exit if price declines by 5% from the entry point
- Short trades: Exit if price increases by 3% from the entry point

•Portfolio Exposure Check:

- Total investment limited to 80% of the portfolio to avoid over-leveraging

Measures for Enhancement:

- **Maximum Portfolio Drawdown Model**
- Limit the maximum loss a portfolio can incur by liquidating positions or reducing exposure when drawdown exceeds a specified threshold
- **Trailing Stop Risk Model**
- Dynamically adapt to price movements and market conditions by adjusting stop-loss price



Backtest Analysis and Performance

Risk Management

Period: January 1 to March 31, 2024 (Q1 2024).

Initial Capital: \$100,000.

Portfolio Composition:

- **100 highly liquid equities.**
- **3 cryptocurrencies:** Bitcoin (BTCUSD), Ethereum (ETHUSD), Solana (SOLUSD).

Real-World Conditions:

- Factored **transaction costs**, **slippage**, and **spreads** for realistic simulation.

•Performance Highlights

•Net Profit:

- 8.14%** over three months.
- Annualized Return: 36.377%.**

•Benchmark Comparison:

- Outperformed major indices in the same period.

•**Sharpe Ratio: 2.093**, indicating strong returns relative to risk.

•**Sortino Ratio: 2.551**, emphasizing controlled downside volatility.



Backtest Analysis and Performance

Key Metrics and Performance Insights

Maximum Drawdown:

- Limited to **7.3%**, showing controlled risk in volatile markets.

Portfolio Beta:

- **0.775**, indicating lower sensitivity to overall market movements.

Turnover Rate:

- **47.12%**, reflecting active trading.
- Transaction fees: **\$1,005.79**, impacting net profits.

Win Rate:

- **45%**, with cumulative gains from winners outweighing losses.

Profit-Loss Ratio:

- **0.43**, highlighting larger average losses than profits.

Expectancy:

- **-0.359**, emphasizing a need for better reward-to-risk management.

Conclusion

•Potential Achieved:

- Strong risk-adjusted returns in a controlled risk framework.

•Next Steps:

- Fine-tune signal accuracy and cost management for scalability and consistency.



Conclusion

Key Takeaways

Performance Highlights:

- Improved **Sharpe Ratios** through:
 - **Shorter maturities** (weekly options).
 - **Dynamic hedging** strategies.
 - Contrarian **Bollinger Band adjustments**.
- Realistic profits estimated with non-ideal execution and liquidity filters.

Challenges Encountered:

- Tail risk events eroded gains.
- Transaction costs and liquidity constraints heavily impacted returns.
- Stability in returns does not guarantee **alpha** after costs.

Future Improvements

- **Advanced Forecasting:**
 - Incorporate machine learning for dynamic hedging and parameter adjustments.
- **Broader Analysis:**
 - Study emerging markets and sector-specific opportunities.
 - Integrate fundamental and sentiment data to anticipate volatility shocks.
- **Strategy Refinement:**
 - Optimize trade frequency to balance costs and returns.
 - Experiment with alternative asset classes.