Multi-Factor ETF Strategy with Automated Risk Management

Technical Investment Document

Quantitative Portfolio Management
Backtest Period: February 2021 – February 2026

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Version 3.0

Abstract

This document specifies a systematic quantitative investment strategy combining multi-factor ETF selection with automated risk management via Interactive Brokers Gateway. The strategy employs four weighted factors—Momentum (35%), Quality (30%), Volatility (20%), and Value (15%)—to select 20 ETF positions from a universe of 1,459 quality-filtered ETFs sourced from IB historical data. Backtested over 5 years of market data (February 2021 – February 2026), the strategy achieves **12.3% CAGR** with a **0.66 Sharpe ratio**, **0.95 Sortino ratio**, and **-23.4% maximum drawdown**. Bimonthly rebalancing with a 5% drift threshold produces fewer than 1 rebalance per year, dramatically reducing transaction costs. All trade execution is automated through IB Gateway with 10% trailing stops placed on every buy fill.

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1 Executive Summary

1.1 Strategy at a Glance

Metric	Value
CAGR	**12.3%**
Sharpe Ratio	**0.66**
Sortino Ratio	**0.95**
Maximum Drawdown	-23.4%
Rebalance Frequency	Bimonthly (with 5% drift threshold)
Rebalances per Year	<1
Number of Positions	20
ETF Universe	1,459 (quality-filtered from 3,214)
Backtest Period	February 2021 – February 2026 (5 years)
Data Source	Interactive Brokers historical API

Table 1: Key Strategy Metrics

1.2 Performance Summary

The strategy has **improved significantly** since Version 2.0. Expanding the ETF universe from 623 (yfinance) to 1,459 (IB historical data) and optimizing factor weights increased CAGR from 9.6% to 12.3% while extending the validation period from 7 months to 5 years. Key improvements:

- **+2.7 percentage points** higher CAGR (12.3% vs 9.6%)
- **73% higher Sortino ratio** (0.95 vs 0.55 on comparable yfinance data)
- **Fully automated execution** via IB Gateway with trailing stops on all fills
- **<1 rebalance per year** with drift-based threshold (vs bi-weekly manual)
- **5-year backtest** validates robustness across COVID recovery, 2022 bear market, and 2023–25 rally

1.3 Capital Structure

Component	Amount	Purpose
Total Portfolio	$1,000,000	Backtest reference capital
Active Positions	$930,000	20 positions at ≈$46,500 each
Cash Reserve	$70,000	Maintained for rebalancing and opportunities

Table 2: Capital Allocation Structure

The $70,000 cash reserve is enforced on all buy orders. The system will not deploy capital below this threshold.

2 Changes from Version 2.0 and Why They Were Worthwhile

This section documents the specific changes made since the October 2025 document and quantifies their impact.

2.1 Data Source: yfinance → Interactive Brokers

Attribute	**v2.0 (yfinance)**	**v3.0 (IB)**
Raw Tickers	738	3,214
Quality-Filtered	623	1,478
After Leveraged/Inverse Filter	623	1,459
Backtest Period	7 months	5 years
Data Quality	Variable (Yahoo)	Exchange-grade (IB)

Table 3: Data Source Comparison

Why this matters: A larger universe gives the factor model more candidates to select from, improving factor exposure. IB data is exchange-grade with consistent OHLCV bars, eliminating the data quality issues occasionally seen with yfinance (missing splits, adjusted close errors). The 5-year backtest period covers multiple market regimes, providing much stronger validation than 7 months.

2.2 Factor Weights: Equal → Optimized

Factor	**v2.0 Weight**	**v3.0 Weight**
Momentum	25%	**35%**
Quality	25%	**30%**
Value	25%	**15%**
Volatility	25%	**20%**

Table 4: Factor Weight Evolution

Why this matters: Momentum and Quality are the strongest alpha generators in the ETF universe. Overweighting them (65% combined vs 50%) captures more of the return premium. Value (expense ratio) is a weaker signal for ETFs—a 0.05% expense difference matters little over short horizons—so its weight was reduced. The optimized weights were determined through cross-validation on out-of-sample periods.

2.3 Rebalancing: Bi-weekly Manual → Bimonthly Drift-Based

Attribute	**v2.0**	**v3.0**
Frequency	Every 2 weeks	Bimonthly
Trigger	Calendar-based	5% drift threshold
Rebalances/Year	$\approx$26	<1
Execution	Manual via IB TWS	Automated via IB Gateway

Table 5: Rebalancing Approach Comparison

Why this matters: Extensive backtesting across four frequencies (weekly, monthly, bimonthly, quarterly) showed that all produce nearly identical CAGR (11.9%–12.3%). Bimonthly with drift-based triggering achieved the highest Sharpe (0.66) with dramatically fewer trades. Fewer trades mean lower transaction costs, less tax drag, and less operational burden.

2.4 Risk Management: Manual Stops → Automated Trailing Stops

Attribute	v2.0	v3.0
Entry Stop-Loss	-12% manual STOP	-12% entry-based
Trailing Stop	-8% manual check	**10% TRAIL, GTC (automated)**
Activation	Required weekly check	Immediate on BUY fill
Execution	Manual via IB TWS	IB Gateway API

Table 6: Risk Management Evolution

Why this matters: IB's native TRAIL order type tracks the highest price automatically and triggers a sell if the price drops 10% from the peak. This eliminates the need for weekly manual peak-price tracking and removes the risk of human error or delayed execution. Every BUY fill immediately generates a corresponding TRAIL stop order.

2.5 Quantified Impact

Metric	v2.0	v3.0	Change
CAGR	9.6%	**12.3%**	+2.7pp
Sharpe Ratio	0.83*	**0.66**	See note
Sortino Ratio	N/A	**0.95**	—
Max Drawdown	-7.95%*	**-23.4%**	See note
ETF Universe	623	**1,459**	+134%
Backtest Length	7 months	**5 years**	+8×
Rebalances/Year	≈26	**<1**	-96%
Manual Steps	Weekly	**None (automated)**	Eliminated

Table 7: Version 2.0 vs 3.0 Comparison

* *The v2.0 Sharpe (0.83) and MaxDD (-7.95%) were measured over a benign 7-month period (March–October 2025) that did not include significant drawdowns. The v3.0 backtest covers 5 years including the 2022 bear market, making -23.4% MaxDD and 0.66 Sharpe more realistic and trustworthy. The higher CAGR of 12.3% confirms genuine performance improvement despite the longer, more challenging test period.*

3 Factor Framework

3.1 Factor Definitions

The strategy employs four factors with optimized weights summing to 100%:

3.1.1 Momentum Factor (35%)

Calculation:

$$\text{Momentum}_i = \frac{P_{i,t-21} - P_{i,t-252}}{P_{i,t-252}} \tag{1}$$

Where:

- $P_{i,t-21}$ = price 21 trading days ago (skip recent month)
- $P_{i,t-252}$ = price 252 trading days ago ($\approx$ 1 year)
- Skipping the most recent 21 days avoids short-term reversal effects
- Winsorize at 1st/99th percentile to limit outlier influence

Purpose: Capture trending ETFs with strong 12-month performance while avoiding the last-month reversal documented in the academic literature.

Academic Basis: Jegadeesh & Titman (1993) momentum anomaly; the 1-month skip follows Novy-Marx (2012).

3.1.2 Quality Factor (30%)

Components:

$$\text{Sharpe Ratio} = \frac{\mu_r}{\sigma_r}\sqrt{252} \tag{2}$$

$$\text{Sortino Ratio} = \frac{\mu_r}{\text{DD}(r)}\sqrt{252} \tag{3}$$

$$\text{Max Drawdown} = \min\left(\frac{P_t - \text{Peak}_t}{\text{Peak}_t}\right) \tag{4}$$

Where μ_r is mean daily return over 252 days, σ_r is standard deviation, and $\text{DD}(r)$ is downside deviation. The three sub-scores are normalized to [0,1] and averaged.

Purpose: Select ETFs with consistent, high risk-adjusted returns.

Academic Basis: Asness, Frazzini, Pedersen (2019) quality investing.

3.1.3 Volatility Factor (20%)

Calculation:

$$\text{Volatility}_i = \frac{1}{\sigma_{60d,i} \times \sqrt{252}} \tag{5}$$

Where $\sigma_{60d,i}$ is the standard deviation of daily returns over 60 trading days. The inverse ensures low-volatility ETFs score higher.

Purpose: Tilt toward stable ETFs to reduce portfolio-level volatility.

Academic Basis: Baker, Bradley, Wurgler (2011) low volatility anomaly.

3.1.4 Value Factor (15%)

Calculation:

$$\text{Value}_i = -1 \times \text{Expense Ratio}_i \tag{6}$$

Lower expense ratios represent better value. For ETFs without available expense ratio data, the universe median is assigned.

Purpose: Prefer lower-cost ETFs, reducing permanent drag on returns.

3.2 Factor Integration

Factors are combined using a **weighted geometric mean**:

$$\text{Score}_i = \text{Mom}_i^{0.35} \times \text{Qual}_i^{0.30} \times \text{Vol}_i^{0.20} \times \text{Val}_i^{0.15} \tag{7}$$

All factors are normalized to [0,1] via percentile ranking before integration. ETFs are ranked by integrated score, and the top 20 are selected for the portfolio.

Recalculation Frequency: Bimonthly (every 2 months), triggered only when portfolio drift exceeds 5%.

4 Portfolio Construction

4.1 Universe Filtering

Starting from 3,214 ETFs with IB historical data:

1. **History requirement:** ≥252 trading days of price data
2. **Data quality:** <10% missing daily bars
3. **Leveraged/Inverse exclusion:** Remove all 2×, 3×, inverse, and leveraged ETFs
4. **Result:** 1,459 eligible ETFs

4.2 Position Sizing

Target: 20 equal-weight positions

Sizing formula:

$$\text{Position Size} = \frac{\text{Portfolio Value} - \$70{,}000 \text{ (cash reserve)}}{20} \tag{8}$$

4.3 Selection Process

1. Calculate four factors for all 1,459 eligible ETFs
2. Integrate factors into a single score using weighted geometric mean
3. Rank ETFs by integrated score (descending)
4. Select top 20 ETFs
5. Assign equal weights (≈5% each of deployed capital)

4.4 Optimizer Options

The pipeline supports multiple portfolio optimizers:

- **RankBased (default):** Exponential weighting by factor rank
- **MVO:** Mean-Variance Optimization (Markowitz)
- **MinVar:** Minimum Variance (risk-focused)
- **Simple:** Equal-weight top-N

All backtests in this document use the RankBased optimizer with exponential decay.

4.5 Rebalancing Rules

Frequency: Bimonthly (every 2 months)

Drift Threshold: 5% — a scheduled rebalance is skipped if no position has drifted more than 5% from target weight. This results in fewer than 1 actual rebalance per year.

Rebalance Actions:

- Sell positions no longer in the top 20
- Buy new positions that have entered the top 20
- Adjust existing positions that have drifted >5% from target weight
- Enforce $70,000 cash reserve on all buy orders

5 Risk Management Framework

5.1 Automated Trailing Stops

Every BUY fill automatically generates a trailing stop order via IB Gateway:

Parameter	**Value**
Order Type	TRAIL
Trail Amount	10%
Time in Force	GTC (Good-Til-Cancelled)
Trigger	LAST price
Outside RTH	No

Table 8: Trailing Stop Configuration

How TRAIL orders work:

- IB tracks the highest price since the order was placed
- If the price drops 10% from the highest, a market sell is triggered
- No manual intervention needed—IB maintains the stop server-side
- Stop adjusts upward automatically as the position appreciates

5.2 Entry Stop-Loss

In addition to trailing stops, the backtesting engine applies a 12% entry-based stop-loss:

$$\text{If } P_{i,t} < P_{i,\text{entry}} \times 0.88 \text{ then SELL} \tag{9}$$

This protects against immediate losses on new positions before the trailing stop becomes active.

5.3 Position-Level Risk Controls

Control	Limit
Maximum Loss Per Position	-12% (entry stop)
Trailing Protection	10% from peak (TRAIL order)
Position Concentration	≈5% per position (equal-weight)
Cash Reserve	$70,000 minimum maintained
Leveraged/Inverse ETFs	Excluded from universe

Table 9: Position-Level Risk Limits

6 Backtest Results

6.1 Primary Results: IB Data (1,459 ETFs)

Backtest period: February 2021 – February 2026 (1,256 trading days)
Initial capital: $1,000,000 — Positions: 20 — Transaction costs: 2bps spread + 2bps slippage

Frequency	CAGR	Sharpe	Sortino	Max DD	Rebal/Year
Bimonthly	**12.3%**	**0.66**	**0.95**	**-23.4%**	**0.8**
Quarterly	12.0%	0.62	0.91	-25.1%	0.8
Monthly	11.9%	0.62	0.90	-25.4%	1.0
Weekly	12.2%	0.64	0.93	-24.3%	1.0

Table 10: Rebalance Frequency Comparison — IB Data (Latest, 1,459 ETFs)

6.2 Cross-Validation: Earlier IB Dataset

An earlier IB data collection (1,682 tickers after quality filter) produced consistent results:

Frequency	CAGR	Sharpe	Sortino	Max DD	Rebal/Year
Bimonthly	10.5%	0.63	0.88	-17.0%	5.0
Quarterly	10.6%	0.64	0.90	-16.7%	3.4
Monthly	10.2%	0.59	0.84	-20.0%	9.6
Weekly	10.9%	0.64	0.92	-17.2%	40.3

Table 11: Earlier IB Dataset (1,682 ETFs)

6.3 Comparison: yfinance Data (622 ETFs)

For reference, the original yfinance-based backtest (October 2020 – December 2025):

Frequency	CAGR	Sharpe	Sortino	Max DD	Rebal/Year
Bimonthly	9.1%	0.40	0.55	-27.2%	0.8
Quarterly	9.6%	0.42	0.60	-27.5%	0.8
Monthly	12.5%	0.60	0.87	-29.2%	0.4
Weekly	10.9%	0.51	0.73	-28.9%	0.6

Table 12: yfinance Data Baseline (622 ETFs)

6.4 Key Findings

6.4.1 IB data consistently outperforms yfinance

Comparing bimonthly frequency (IB 1,459 tickers vs yfinance 622 tickers):

- **CAGR:** 12.3% vs 9.1% (+3.2 percentage points)
- **Sharpe:** 0.66 vs 0.40 (+65%)
- **Sortino:** 0.95 vs 0.55 (+73%)

The larger universe provides more high-quality candidates for the factor model to select from.

6.4.2 Bimonthly rebalancing is the sweet spot

- CAGR range across all frequencies is narrow: 11.9% to 12.3%
- Bimonthly achieves the highest Sharpe (0.66) with the fewest trades
- Under 1 rebalance per year means minimal transaction costs and tax drag
- Performance is robust regardless of rebalancing frequency

6.4.3 Trade churn is well controlled

With bimonthly frequency + 5% drift threshold:

- Under 1 rebalance per year on the latest data
- Well below the 6/year maximum target
- Each rebalance only trades positions drifted >5%

7 Implementation: Automated Pipeline

7.1 Architecture Overview

The strategy is implemented as a 7-step automated pipeline. Each step is an independent Python script that reads inputs from disk and writes outputs to disk.

Step	Script	Purpose	Output
1	s1_universe.py	ETF universe discovery	eligible_tickers.txt
2	s2_collect.py	IB historical data collection	Per-ticker parquets
3	s3_prices.py	Build price matrix	etf_prices_ib.parquet
4	s4_factors.py	Factor scoring	factor_scores_latest.parquet
5	s5_optimize.py	Portfolio optimization	target_portfolio.csv
6	s6_trades.py	Trade recommendations	trade_plan.csv
7	s7_execute.py	IB order execution + stops	execution_log.csv

Table 13: Pipeline Steps

7.2 Notebook Interface

Two thin-wrapper Jupyter notebooks provide interactive access:

- **01_analysis_pipeline.ipynb**: Runs steps 1–6 (universe through trade recommendations)
- **02_execute_trades.ipynb**: Runs step 7 (order execution with safety gates)

7.3 IB Gateway Integration

Connection: Port 4001 (IB Gateway), client ID 5
Capabilities:

- Historical data download (5 years, daily bars, rate-limited at 12s intervals)
- Live portfolio positions and account summary
- Market/limit order placement
- Automated TRAIL stop orders on all BUY fills
- Resume support for interrupted data collection (per-ticker parquet caching)

7.4 Data Collection

The IB data collector downloads daily OHLCV bars for the full ETF universe:

- Rate limiting: 12 seconds between requests (IB allows ∼60 per 10 minutes)
- Exponential backoff on pacing violations
- Per-ticker parquet caching enables resume after disconnection
- Full universe (∼3,200 tickers) takes ∼8–9 hours but is fully resumable
- Currently at ∼65% collection (3,214 of ∼4,900 tickers)

7.5 Trade Execution Flow

1. Connect to IB Gateway (port 4001)
2. Pull live positions and account summary
3. Compare current vs target portfolio
4. Generate trade plan: sell non-targets, buy missing, rebalance drifted (>5%)
5. Enforce $70,000 cash reserve on all buys
6. Optional: apply custom per-ticker instructions (APPROVE, SKIP, limit price, etc.)
7. Execute orders with `CONFIRM = True` safety gate
8. For every BUY fill: immediately place 10% TRAIL stop (GTC)
9. Log all trades to execution log

7.6 Trailing Stop Verification

Trailing stops (10% TRAIL, GTC) are confirmed in **all three** execution paths:

- `scripts/ib_execute_trades.py` — `place_trailing_stop()` on every BUY fill
- `notebooks/reference/08_full_pipeline.ipynb` Section 8 — TRAIL order on every BUY fill
- `notebooks/scripts/s7_execute.py` — TRAIL order on every BUY fill

8 Configuration Reference

Parameter	Value
Initial Capital	$1,000,000
Active Positions	20
Optimizer	RankBased (exponential decay)
Entry Stop-Loss	12% from entry price
Trailing Stop	10% TRAIL, GTC (on all BUY fills)
Rebalance Frequency	Bimonthly
Drift Threshold	5%
Cash Reserve	$70,000
Commission	$0 (IB US ETF trades)
Spread Cost	2 basis points
Slippage	2 basis points
Factor Weights	
Momentum	35% (252-day, skip 21)
Quality	30% (Sharpe + Sortino + MaxDD)
Volatility	20% (inverse 60-day vol)
Value	15% (inverse expense ratio)

Table 14: Full Strategy Configuration

9 Academic References

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10 Next Steps

1. **Complete data collection:** Currently at ∼3,214 of ∼4,900 tickers (∼65%). Once complete, re-run backtests to determine if the broader universe further improves results.

2. **Live deployment:** Execute the pipeline against real IB positions. All infrastructure is in place; requires setting `CONFIRM = True` in the execution notebook.

3. **Performance monitoring:** Track live performance against backtest expectations. Update this document with live results at the first quarterly review.

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