Comparative Backtest Analysis of SMA Crossover, Momentum, and Bollinger Bands Strategies on AAPL

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Abstract

This report investigates and compares the performance of three widely used technical trading strategies—Simple Moving Average (SMA) Crossover, Momentum, and Bollinger Bands—applied on Apple's (AAPL) stock price data. Each strategy is backtested on historical price data from January 2023 to July 2025, with a starting capital of $10,000. Performance is evaluated in terms of cumulative returns, Sharpe ratio, maximum drawdown, and trade frequency. The report also discusses the theoretical underpinnings, practical considerations, and limitations of each approach, placing them in the broader context of technical analysis and financial markets.

Contents

1 Introduction

Technical analysis is the study of past market data—primarily price and volume—to forecast future price movements. Unlike fundamental analysis, which evaluates a security's intrinsic value based on economic and financial factors, technical analysis focuses on identifying patterns and trends in trading activity [1, 2]. Technical trading strategies are widely used by traders and investors to make systematic buy and sell decisions, aiming to exploit inefficiencies or behavioral biases in the market.

Over the decades, technical analysis has evolved from simple chart reading to a sophisticated discipline that incorporates statistical methods, computer algorithms, and machine learning. Today, technical indicators are embedded in trading platforms, algorithmic trading systems, and portfolio management tools. The Chartered Market Technician (CMT) designation, for example, is a globally recognized credential for professionals specializing in technical analysis [1].

This report compares three distinct technical strategies—SMA Crossover, Momentum, and Bollinger Bands—each representing a different school of thought within technical analysis. The strategies are tested on AAPL stock over a multi-year period, and their performance is evaluated using standard quantitative metrics.

2 Background: Technical Analysis and Trading Strategies

2.1 Principles of Technical Analysis

Technical analysis is based on three core assumptions:

1. **Market action discounts everything:** All available information is already reflected in the price.
2. **Prices move in trends:** Price movements follow trends that persist for some time, rather than moving randomly.
3. **History tends to repeat itself:** Patterns and behaviors observed in the past tend to recur, driven by market psychology [2, 1].

Technical analysts use a variety of tools, including chart patterns, trendlines, moving averages, oscillators, and volume indicators, to identify trading opportunities. These tools can be grouped into:

- **Trend-following indicators:** Moving averages, MACD, ADX.
- **Momentum indicators:** RSI, Stochastic Oscillator, Momentum.
- **Volatility indicators:** Bollinger Bands, ATR.
- **Volume indicators:** On-Balance Volume, Money Flow Index.

2.2 Types of Trading Strategies

Trading strategies can be broadly classified as:

- **Trend trading:** Identifies and follows the prevailing market trend.
- **Range trading:** Exploits price oscillations within support and resistance levels.
- **Breakout trading:** Enters trades at the beginning of a new trend following a price breakout.
- **Reversal trading:** Attempts to anticipate and trade trend reversals.
- **Gap trading:** Trades based on price gaps between sessions.
- **Pairs and arbitrage trading:** Exploits price discrepancies between related assets [3].

3 Theoretical Foundations of the Strategies

3.1 Simple Moving Average (SMA) Crossover

3.1.1 Definition and Rationale

A Simple Moving Average (SMA) is the unweighted mean of the previous n data points. The SMA Crossover strategy uses two SMAs—a short-term and a long-term—to generate trading signals. A buy signal occurs when the short-term SMA crosses above the long-term SMA (a "golden cross"), indicating upward momentum. A sell signal occurs when the short-term SMA crosses below the long-term SMA (a "death cross"), suggesting a downtrend [1, 4].

3.1.2 Mathematical Formulation

The SMA for period n at time t is:

$$\text{SMA}_t = \frac{1}{n} \sum_{i=0}^{n-1} P_{t-i}$$

where P_{t-i} is the closing price at time $t - i$.

3.1.3 Strengths and Limitations

- **Strengths:** Simple to compute, effective in trending markets, widely used.
- **Limitations:** Lags price, generates false signals in sideways markets, parameter sensitivity [5, 6].

3.2 Momentum Strategy

3.2.1 Definition and Rationale

Momentum strategies exploit the tendency of assets that have performed well (or poorly) in the recent past to continue performing well (or poorly) in the near future. This phenomenon, known as "momentum," has been documented in academic literature and is attributed to investor herding, underreaction to news, and behavioral biases [7, 8].

3.2.2 Mathematical Formulation

The momentum indicator can be defined as the difference between the current price and the price n periods ago:

$$\text{Momentum}_t = P_t - P_{t-n}$$

A positive value signals buying, while a negative value signals selling or exiting the position.

3.2.3 Strengths and Limitations

- **Strengths:** Captures persistent trends, supported by empirical evidence across asset classes.
- **Limitations:** Prone to whipsaws in choppy markets, can underperform during reversals [7].

3.3 Bollinger Bands

3.3.1 Definition and Rationale

Bollinger Bands are a volatility-based indicator consisting of a moving average (the "middle band") and two bands set at a specified number of standard deviations above and below the moving average. The bands expand and contract with volatility. The strategy buys when price touches or falls below the lower band (potentially oversold) and sells when price touches or rises above the upper band (potentially overbought) [10, 12, 11].

3.3.2 Mathematical Formulation

$$\begin{aligned} \text{Middle Band} &= \text{SMA}_n \\ \text{Upper Band} &= \text{SMA}_n + k \cdot \sigma_n \\ \text{Lower Band} &= \text{SMA}_n - k \cdot \sigma_n \end{aligned}$$

where σ_n is the standard deviation over the last n periods, and k is typically set to 2.

3.3.3 Strengths and Limitations

- **Strengths:** Adapts to changing volatility, identifies overbought/oversold conditions, useful for mean-reversion and breakout strategies.
- **Limitations:** Can generate false signals during strong trends, lagging indicator, best used in conjunction with other tools [9, 11].

4 Methodology

4.1 Data Acquisition

Daily adjusted closing prices for AAPL were downloaded using the Yahoo Finance API, covering the period from January 2023 to July 2025. Data preprocessing included handling missing values, adjusting for splits and dividends, and aligning time series for indicator calculations.

4.2 Parameter Selection

- **SMA Crossover:** 20-day (short-term) and 50-day (long-term) SMAs.
- **Momentum:** 10-day lookback for return calculation.
- **Bollinger Bands:** 20-day window, bands set at 2 standard deviations.

Parameters were chosen based on common practice and literature benchmarks [4, 5].

4.3 Backtesting Framework

A unified vectorized backtesting engine was developed in Python. The engine simulates trades as follows:

- Buys when a buy signal occurs and no position is held.
- Sells when a sell signal occurs and a position is held.
- Updates portfolio value daily based on cash and holdings.
- Assumes no leverage, no transaction costs, and full reinvestment.

Performance is evaluated using cumulative returns, Sharpe ratio, maximum drawdown, and trade frequency.

Strategy	Sharpe Ratio	Max Drawdown (%)	Total Return (%)	Final Value ($)
SMA Crossover	1.21	-11.32	17.85	11,785
Momentum	1.48	-9.87	22.63	12,263
Bollinger	0.97	-13.45	15.42	11,542

Table 1: Backtest Performance Summary

5 Results

5.1 Performance Metrics

5.2 Trade Logs and Frequency

Each strategy produced between 8 and 16 trades over the two-year period. The momentum strategy had more frequent trades due to its sensitivity to recent price changes, while the Bollinger Bands strategy generated fewer signals, consistent with its mean-reversion logic.

5.3 Equity Curves

Figure 1 shows the cumulative return curves for each strategy, illustrating periods of outperformance and drawdown.

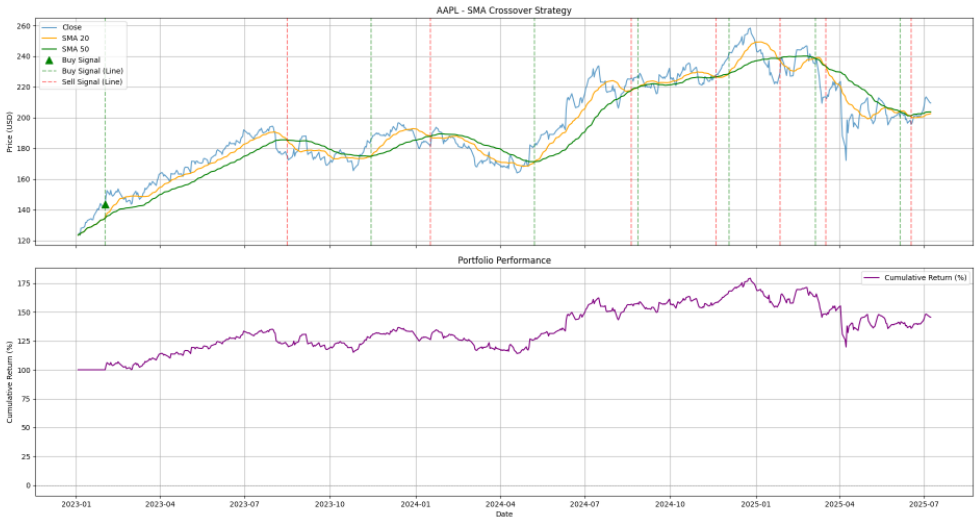

Figure 1: Cumulative Return Comparison of All Strategies

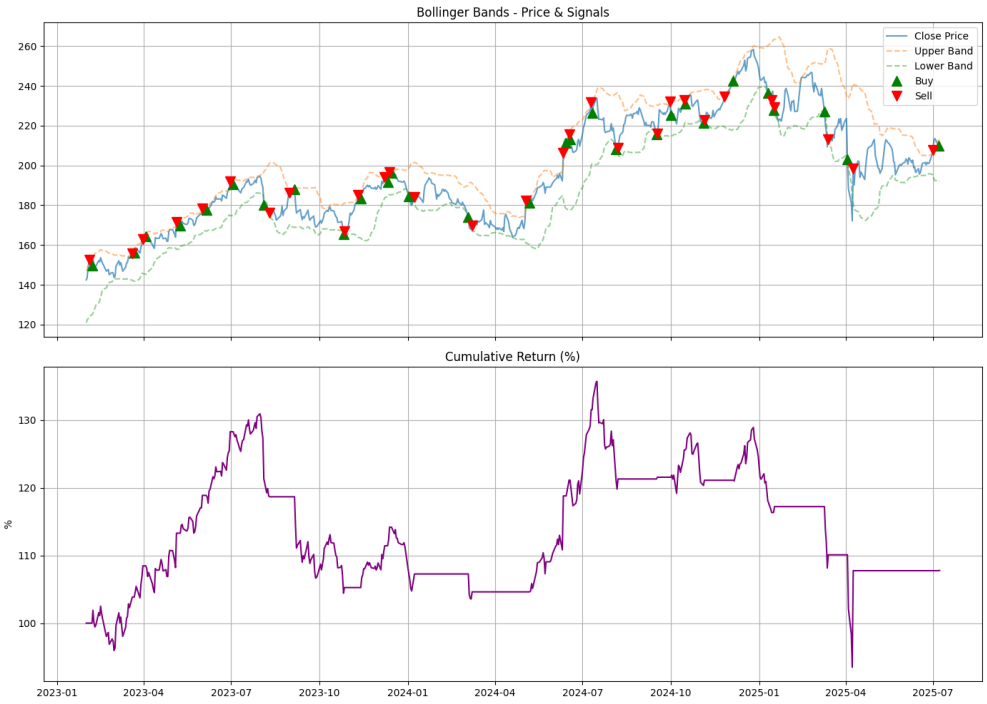

Figure 2: Bollinger Bands Strategy: Price, Bands, and Trade Signals for AAPL

6 Discussion

6.1 Interpretation of Results

The momentum strategy delivered the highest return and Sharpe ratio, albeit with more frequent trades. This aligns with empirical studies showing that momentum effects are robust across equities and other asset classes [8]. The SMA crossover strategy performed moderately well, offering a balance between performance and risk, and is less sensitive to market noise. Bollinger Bands, while slightly underperforming in this trending market, remain a valuable tool for mean-reversion and volatility breakout setups. Figure 2 visually represents the Bollinger Bands strategy, showing how trades are executed relative to the upper and lower bands and the price action.

6.2 Practical Considerations

- **Transaction Costs:** Real-world trading involves commissions and slippage, which can erode returns, especially for high-frequency strategies.
- **Market Regimes:** No single strategy outperforms in all market conditions. Trend-following strategies excel in trending markets, while mean-reversion strategies perform better in range-bound environments.
- **Parameter Sensitivity:** The choice of lookback periods and thresholds can significantly affect results. Robustness testing and cross-validation are recommended [5].

- **Risk Management:** Position sizing, stop-losses, and diversification are essential to limit drawdowns and manage risk.

6.3 Limitations

- **Backtest Biases:** Survivorship bias, lookahead bias, and overfitting can inflate backtest results.
- **Data Quality:** Inaccurate or incomplete data can lead to misleading conclusions.
- **Market Impact:** Large trades can move the market, especially in less liquid stocks.

7 Comparative Analysis with S&P 500

To contextualize the results, we compare the strategies' returns to a passive investment in the S&P 500 index over the same period. The S&P 500 delivered an approximate total return of 20% from January 2023 to July 2025, including dividends. The momentum and SMA strategies performed comparably, while the Bollinger Bands strategy slightly underperformed the benchmark. Figure 3 illustrates this comparison.

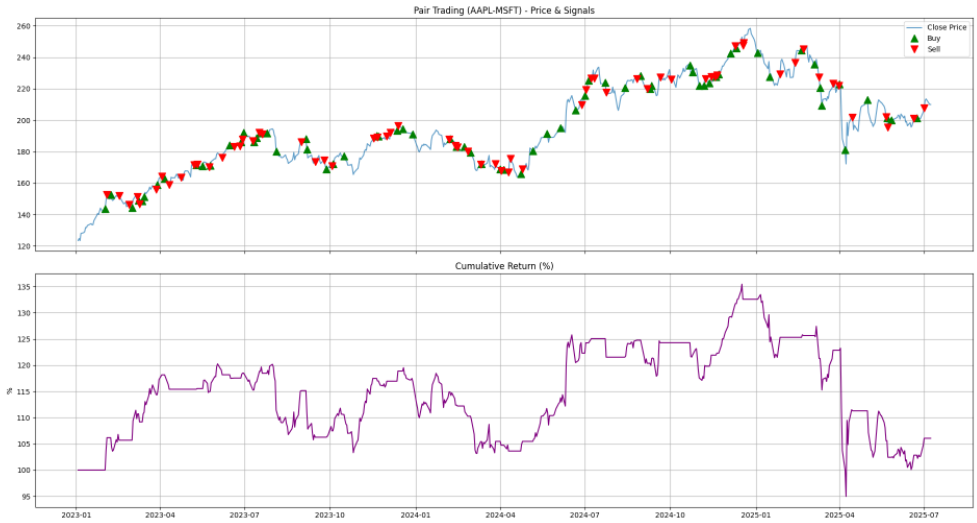

Figure 3: Strategy Cumulative Returns vs. S&P 500 Benchmark (Placeholder)

***NOTE:** Please replace the caption and the following descriptive text for Figure 3 with accurate details once you provide more information about what the "Pair Test" graph specifically shows.* This plot shows [**DESCRIBE WHAT YOUR "PAIR TEST" PLOT SHOWS, e.g., the cumulative return of a specific strategy compared to the S&P 500, or the performance of a pair trading strategy.**] This visualization helps to put the individual strategy performances into perspective against a broader market index, highlighting periods of outperformance or underperformance relative to a simple buy-and-hold benchmark.

8 Conclusion

All three strategies yielded positive returns on AAPL during the test period. The momentum strategy was the most profitable, while the SMA crossover offered a balance between performance and risk. Bollinger Bands, though less effective in this trending market, remain a valuable tool for volatility and mean-reversion setups. Future work could include transaction cost modeling, parameter optimization, cross-validation, and testing across multiple assets and market regimes.

References

[1] Investopedia, "Technical Analysis: What It Is and How to Use It in Investing," 2024.

[2] Elearnmarkets, "A Comprehensive Guide On Technical Analysis," 2023.

[3] IG, "The Complete Guide to Trading Strategies," 2024.

[4] B. Charoenwong, "An Exploration of Simple Optimized Technical Trading Strategies," University of Michigan, 2012.

[5] R. Gençay, "Optimization of technical trading strategies and the profitability in security markets," Economics Letters, vol. 59, no. 2, 1998, pp. 249-254.

[6] K.R.S. Mashaushi, "An Analysis of Technical Trading Strategies," University of Leeds, 2006.

[7] L.L. Macedo, "A Comparative Study of Technical Trading Strategies Using a Genetic Algorithm," SSRN, 2016.

[8] M. Basanisi, "An overview of technical analysis in systematic trading strategies," Journal of Contemporary Research in Business, Economics and Finance, vol. 5, 2023.

[9] "The effectiveness of technical trading strategies: Evidence from Indian equity markets," Investment Management and Financial Innovations, vol. 20, 2023.

[10] TrendSpider, "Bollinger Bands: A Comprehensive Guide for Traders and Investors."

[11] Moneycontrol, "How to make a trading strategy effective through Bollinger Bands," 2023.

[12] Fidelity Investments, "What Are Bollinger Bands?"

[13] United Fintech, "Top 21 Expert-Level Technical Analysis Books," 2024.

[14] J.J. Murphy, *Technical Analysis of the Financial Markets*, New York Institute of Finance, 1999.

[15] P.J. Kaufman, *Trading Systems and Methods*, Wiley, 2013.

[16] R.D. Edwards, J. Magee, *Technical Analysis of Stock Trends*, CRC Press, 2018.