Statistical Validation of a Moving Average Crossover Strategy

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Abstract

This paper rigorously evaluates the performance and statistical significance of a moving average crossover strategy applied to financial time series. The strategy is tested across different market regimes, including the COVID-19 Crash Recovery and the Quantitative Easing Bull Market period. We analyze total return and Sharpe ratio, investigating the presence of data snooping bias and its mitigation through cross-validation techniques. Results demonstrate that while some parameter configurations yield high Sharpe ratios in specific periods, robustness remains a concern. Additionally, we acknowledge that trading commissions are not included in this analysis, which could significantly impact returns, particularly for short positions. The strategy's performance across both bull and bear markets suggests its applicability to various market conditions, including equities and cryptocurrencies.

1 Methodology

Moving average crossover strategies are widely used in financial trading as a trend-following technique. By comparing a short-term and a long-term moving average, traders aim to identify buy and sell signals. This study evaluates the effectiveness of such a strategy across multiple market conditions, emphasizing the risks associated with data snooping bias.

Given a time series of asset prices $\{P_t\}_{t=1}^{T}$, the moving averages are defined as:

$$\text{Short-MA}(t) = \frac{1}{N_s} \sum_{i=t-N_s+1}^{t} P_i, \tag{1}$$

$$\text{Long-MA}(t) = \frac{1}{N_l} \sum_{i=t-N_l+1}^{t} P_i, \tag{2}$$

where N_s and N_l denote the window lengths for the short and long moving averages, respectively, with $N_s < N_l$.

The trading signals are:

$$\begin{aligned} \text{Long signal:} \quad & \text{if Short-MA}(t) > \text{Long-MA}(t), \\ \text{Short signal:} \quad & \text{if Short-MA}(t) < \text{Long-MA}(t). \end{aligned}$$

The portfolio return at time t is:

$$R_t = S_t \cdot \frac{P_t - P_{t-1}}{P_{t-1}}, \tag{3}$$

where $S_t \in \{-1, 0, 1\}$ represents the trading position.

Total return over period $[1, T]$:

$$R_{\text{total}} = \prod_{t=1}^{T} (1 + R_t) - 1. \tag{4}$$

The Sharpe ratio, measuring risk-adjusted return, is:

$$S = \frac{\mathbb{E}[R_t]}{\sigma(R_t)} \sqrt{252}. \tag{5}$$

2 Results and Discussion

One of the primary challenges in strategy optimization is the risk of *data snooping bias*, where repeated testing on historical data leads to overfitting. This occurs when we search for the best-performing short and long moving average values over an entire dataset and select the combination yielding the highest return. In reality, these optimal parameters are unknown in a live trading environment, and their selection should be robust across unseen data.

To address this issue, we propose *cross-validation* as a solution. Instead of evaluating the strategy on the full dataset, we divide the historical data into multiple folds. For each fold:

1. A subset of the data is designated as the *training set*, used to determine the optimal short and long MA parameters.

2. The remaining portion is used as the *validation set* to assess out-of-sample performance.

3. The process is repeated across multiple rolling windows, and the final parameter selection is based on average performance across all validation sets.

This methodology prevents the model from overfitting to a specific period and ensures that parameter selection generalizes across different market conditions.

Table 1 summarizes the performance of the optimized strategy under cross-validation:

Figures 1 and 2 illustrate the cumulative return performance of SPY and QQQ under the COVID-19 Crash Recovery and Quantitative Easing Bull Market periods, respectively.

Market Regime	Asset	Total Return	Sharpe Ratio
COVID-19 Crash Recovery	SPY	59.99%	1.98
	QQQ	65.36%	1.53
Quantitative Easing Bull Market	SPY	79.46%	0.78
	QQQ	140.94%	0.93

Table 1: Performance metrics under cross-validation.

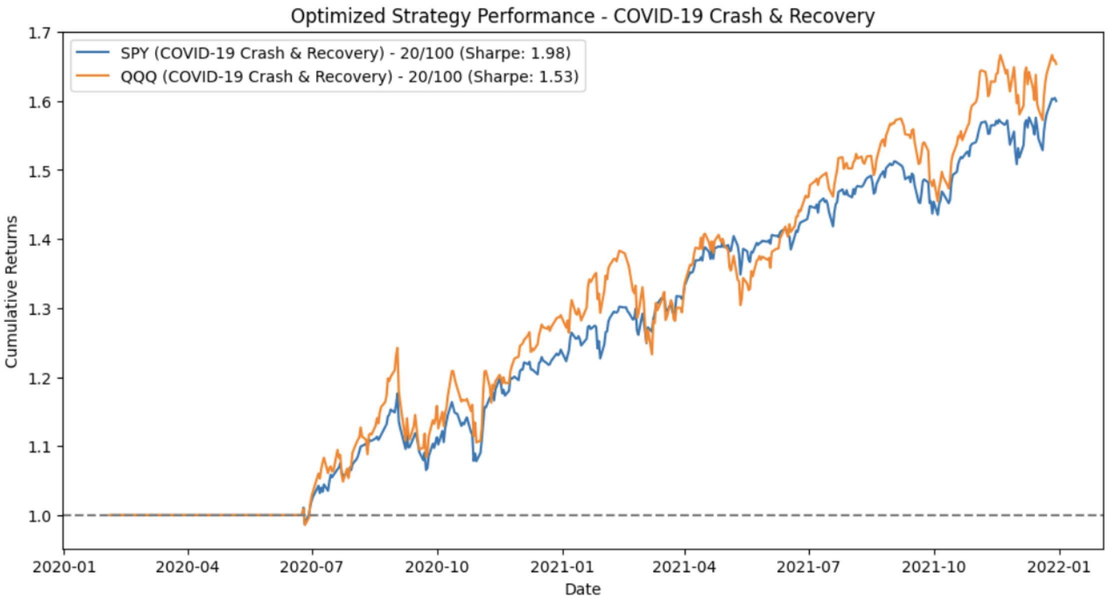

Figure 1: Optimized Strategy Performance - COVID-19 Crash Recovery

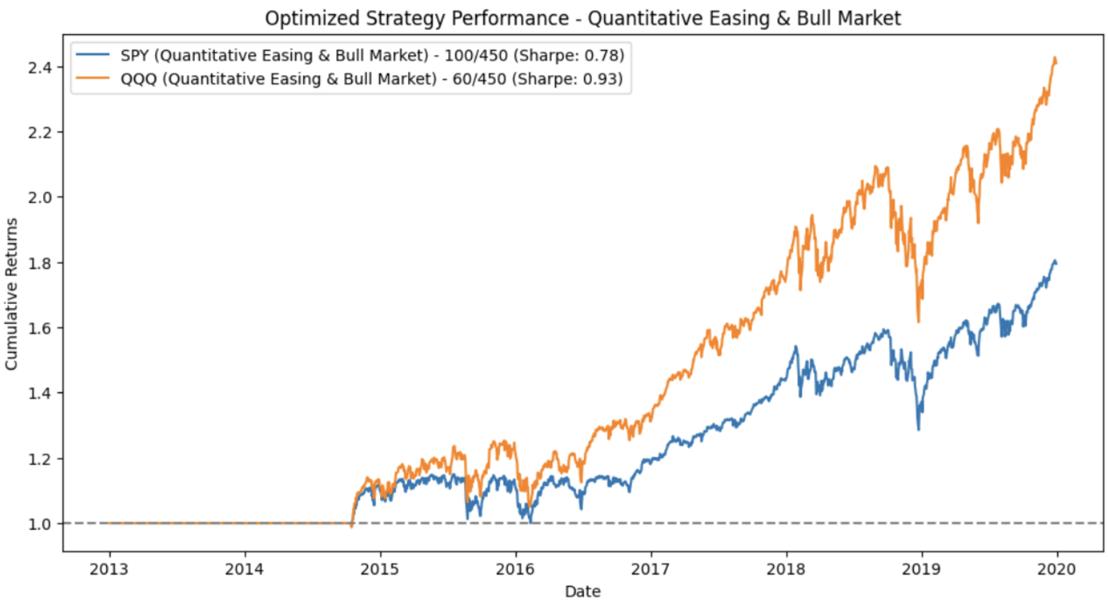

Figure 2: Optimized Strategy Performance - Quantitative Easing Bull Market

3 Conclusion

This paper rigorously assesses a moving average crossover strategy across different market regimes. While results demonstrate significant profitability during both bull and bear markets, we emphasize the importance of avoiding data snooping bias. Additionally, we acknowledge that this study does not incorporate trading commissions, which could substantially impact net returns, particularly for short-selling strategies where borrowing costs may apply. Cross-validation provides a robust framework for selecting optimal moving average parameters that generalize to unseen data. Future research could explore alternative approaches, such as the Superior Predictive Ability test (Hansen, 2005), to further validate robustness. The versatility of this strategy suggests potential applicability to other asset classes, including individual stocks and cryptocurrencies.

References

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