

1. INTRODUCTION

Four techniques used to evaluate investment strategies are:

- 1) **Backtesting** – tests strategy in historical setting over long-periods.
- 2) **Historical Scenario Analysis** (a.k.a. Historical Stress Testing) – tests effectiveness of the strategy in discrete historical environment
- 3) **Simulation** – tests the performance of strategy in a user defined hypothetical environment.
- 4) **Sensitivity Analysis** – combined with simulation to discover the effects of changing assumptions.

2. THE OBJECTIVES OF BACKTESTING

Backtesting is a widely accepted process used by analysts to evaluate a strategy's performance using **historical data**.

In backtesting, managers assume that they can go back in time, apply their investment strategy, rebalance their portfolio and measure performance.

implied assumption is that the future will resemble history to some extent.

However, there is no guarantee that strategies that perform well (poor) in a backtest will (will not) produce excess returns in the future.

For an investment strategy, backtesting is typically employed as **acceptance** or **rejection** criteria. The

3. THE BACKTESTING PROCESS

Backtesting Flowchart		
1.	Strategy Design	<ul style="list-style-type: none"> • Specify investment hypothesis & goals • Determine investment rules & process • Select key parameters
2.	Historical Investment Simulation	<ul style="list-style-type: none"> • Construct investment portfolio for each period based on the rules specified in step 1. • Rebalance portfolios periodically based on pre-determined rules
3	Analysis of Backtesting Output	<ul style="list-style-type: none"> • Calculate portfolio performance statistics • Compute other key metrics

Reference: Wolfe Research Luo's QES.

3.1 Step 1: Strategy Design

1. Specify investment hypothesis and goals.

- o Goals – for example, achieving excess return above the benchmark.
- o Investment hypothesis - a method or criteria to achieve the goal.

- 2. Determine investment rules & process.
- 3. Select key parameters. Some key parameters are provided below:

3.1.1) Investment Universe

Specify the investment universe. The investment universe includes all potential securities available for investment.

3.1.2) Return Definition

Specify the benchmark and determine in which currency the returns will be computed (when the investment universe includes securities from multiple countries).

3.1.3) Rebalancing Frequency and Transaction Cost

- Decide frequency for portfolio rebalancing.
- As rebalancing involves costs, the frequency decision should be based on cost versus benefit trade-off.
- Monthly frequency for portfolio rebalancing is usually common.

3.1.4) Start and End Date

- Select the start and end dates of the backtesting process.
- Investment managers prefer to backtest strategies using a larger sample (i.e., long history).
- However long data history creates the non-stationarity issue.

Practice: Example 1, Reading 41, CFA Institute's Curriculum.



3.2 Step 2: Historical Investment Simulation

1. Construct investment portfolio for each period based on the rules specified in step 1. Portfolio construction depends primarily on:

- Investment hypothesis
- Manager's capabilities and styles
- Client's investment mandate

2. Rebalance portfolios periodically based on pre-determined rules.

To simulate rebalancing, rolling windows approach is typically used.

Rolling windows – is a backtesting method that uses rolling window structure to rebalance portfolio after each period and then tracks the performance overtime.

In *rolling window structure*, the strategy uses data from a historical in-sample period. Then the data is tested on out-of-sample period. The process is repeated as time moves forward.

This approach replicates 'live investing process' as managers adjust/revise their positions for new information.

3.3 Step 3: Analysis of Backtesting Output

1. Calculate portfolio performance statistics

- generating results (average return, risk profiles) for presentation and interpretation purposes.
- Metrics used may include, Sharpe ratio, Sortino ratio, volatility, maximum drawdown etc.

2. Compute other key metrics:

Visuals - (charts, distributions, graphs)– an intuitive way to summarize datapoints and to examine cumulative backtested performance over an extended history.

For example, cumulative performance graphs using logarithmic scale help in identifying downside risk, performance decay and structural breaks/regime changes.

Examples of structural breaks are depression, recession, geopolitical events, major shifts in monetary/fiscal policies, technological changes etc.

Practice: Example 2, Reading 41, CFA Institute's Curriculum.



4. BACKTESTING MULTIFACTOR MODELS

Most investment managers use multifactor structures and filters (instead of single factor) in their stock screening tools.

The following two multifactor equity portfolio strategies are discussed under this section.

1. Backtesting a benchmark (BM) factor portfolio with equal weights
2. Risk parity (RP) factor portfolio with equal risk weights.

Both these strategies are backtested by applying the same three steps described under section 3.

4.1 Step 1: Strategy Design

4.2 Step 2: Historical Investment Simulation

4.3 Step 3: Output Analysis

For illustration refer to the CFA Institute's Curriculum, Reading 41, Section 4.

Practice: Example 3 and 4, Reading 41, CFA Institute's



5. COMMON PROBLEMS IN BACKTESTING

5.1 Survivorship Bias

Survivorship bias occurs when the database used in back-testing excludes companies that cease to exist due to a merger or bankruptcy, and consequently include only remaining/surviving companies. It leads to overstated performance.

It is recommended to backtest all companies that have ever existed in the exact point in time manner.

Point-in-time data: when analysts use all-inclusive data for any given prior time period to backtest the most realistic investment strategies.

Point-in-time data take into account '**low volatility anomaly**', which states that low volatility stocks tend to outperform high volatility stocks.

5.2 Look-Ahead Bias

Look-ahead bias occurs when the database used in backtesting includes information that was unavailable during the historical period.

- It is the most common bias made by practitioners.
- Common forms of look-ahead bias may include reporting lags, data revisions, index additions etc.
- It can be overcome by using point-in-time data.

- Survivorship bias is a sub-type of look-ahead bias.

5.3 Data Snooping

Data snooping bias -*overanalyzing the data in an attempt to find the desired results:*

- Data snooping occurs when intentionally or unintentionally data is manipulated in a way to produce statistically significant results.
- It is also called p-hacking
- The ultimate results of data snooping are often false positives.

Data snooping can be mitigated by:

- setting the higher hurdle than normal (i.e., to determine whether a new factor is statistically significant).
- cross-validation – data is partitioned into training data and validation/testing data. The model built from training data is tested for validation data.

Practice: Example 5 & 6, Reading 41, CFA Institute's Curriculum.



6. HISTORICAL SCENARIO ANALYSIS

Historical scenario analysis is a type of backtesting that helps to assess the effects of regime changes and structural breaks on the performance and risk of the investment strategy.

Two common types of regime changes are:

1. Expansions and recessions
2. High-and low-volatility regimes

7. SIMULATION ANALYSIS

Backtesting is based on the assumption that the past is expected to reoccur in future.

As financial markets are highly dynamic, **Simulation** provides a more complete picture than backtesting.

Two basic types of simulation are:

1. Historical Simulation
2. Monte Carlo Simulation

Historical simulation uses past return data but randomly change the sequencing of historical periods.

- Like rolling window backtesting, historical simulation implicitly assumes that the distribution of past returns is a good representation of expected future returns.
- Unlike backtesting, in historical simulation, historical period returns are selected without time ordering.

- Therefore, Historical Simulation is considered as 'non-deterministic rolling-window backtest.'

In Monte Carlo Simulation, each key variable is assigned an assumed statistical distribution, and observations are drawn from these assigned distributions.

Because of this assumed statistical distribution feature, Monte Carlo simulation allow analysts to incorporate non-normality, fat tails, tail dependence etc.

Monte Carlo simulation:

- is popular because it is very flexible.
- is complex and computationally intensive.
- does not rely on past data in forecasting future data, unlike historical simulation.

Limitation:

Monte Carlo simulation assumes a multivariate normal distribution as a starting point.

7.1

Historical Simulation

For illustration refer to the CFA Institute's Curriculum, Reading 41, Section 7.1.

7.2

Monte Carlo Simulation

For illustration refer to the CFA Institute's Curriculum, Reading 41, Section 7.2.

Practice: Example 7, Reading 41, CFA Institute's Curriculum.



8.

SENSITIVITY ANALYSIS

Sensitivity analysis can be used to examine how the target variables and risks are affected by changes in input variables.

Sensitivity analysis explains limitation of Monte Carlo simulation (assuming multivariate normal distribution as a starting point).

For illustration refer to the CFA Institute's Curriculum, Reading 41, Section 8.

Practice: Example 8, Reading 41, CFA Institute's Curriculum.



Practice: CFA Institute's end of Chapter Questions + Questions from FinQuiz Question-bank.

