



INTRODUCTION TO PORTFOLIO ANALYSIS

Modern Portfolio Theory of Harry Markowitz

Portfolio Weights Are Optimal...

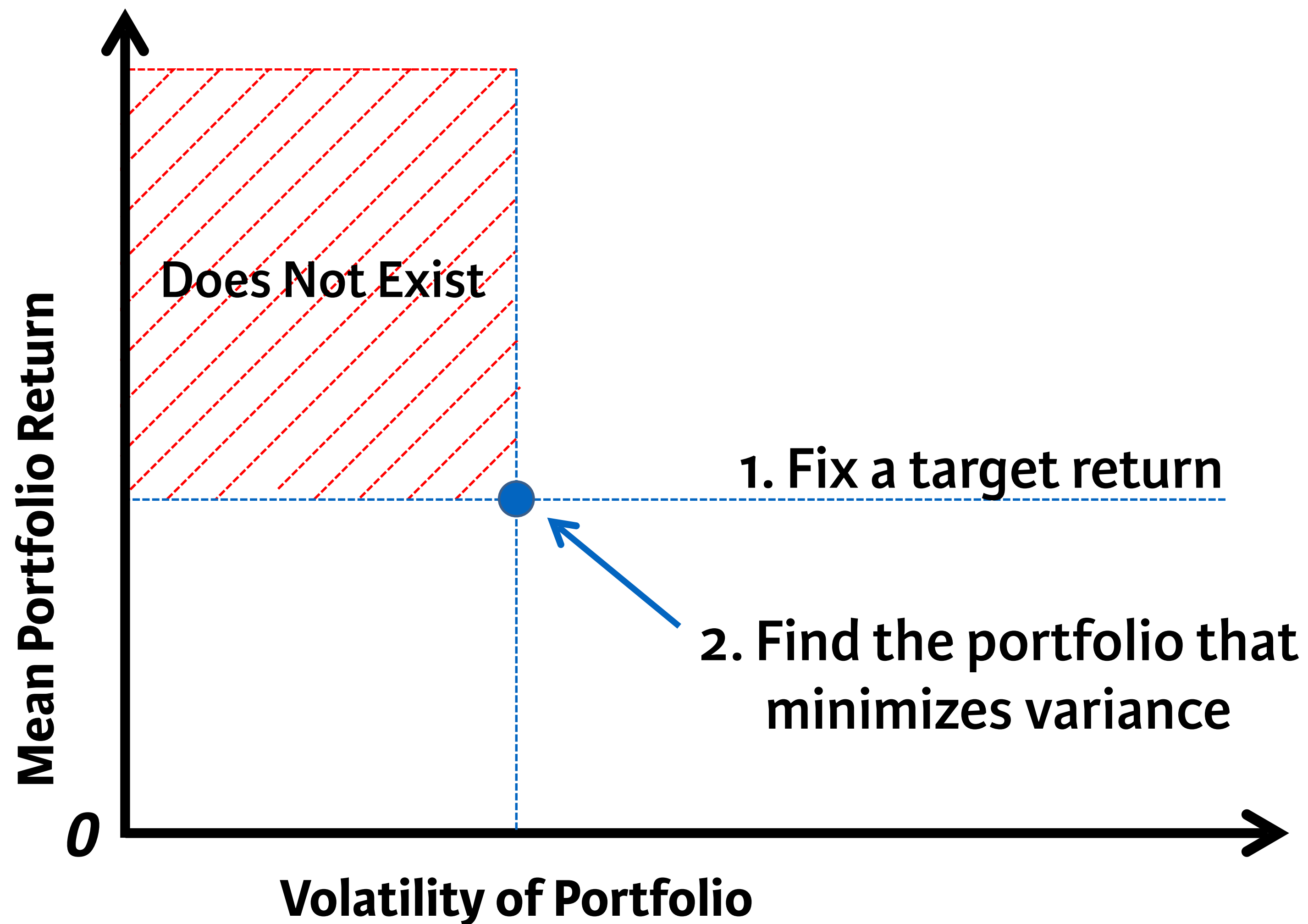
... when they optimize an objective function while satisfying the constraints

Possible Objectives	Possible Constraints
Maximize expected return	Only positive weights
Minimize the variance	Weights sum to 1 (all capital needs to be invested)
Maximize the Sharpe Ratio	Portfolio expected return equals a target value

Harry Markowitz

- Nobel Prize Winner
- Recommends finding optimal portfolios by minimizing portfolio variance
 - Constraint: Expected return should be equal to a pre-specified target return

The H. Markowitz Approach





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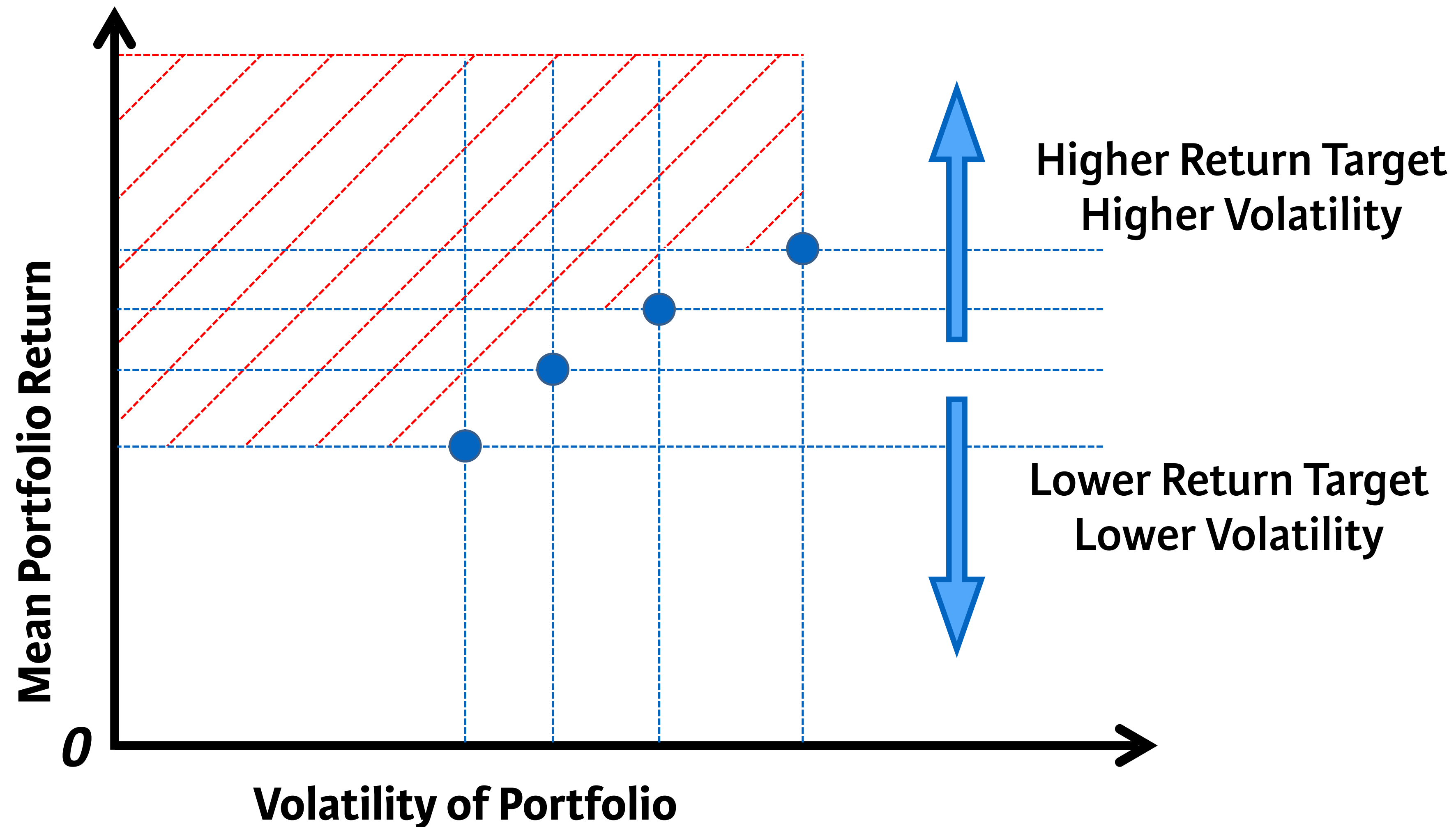
Let's practice!



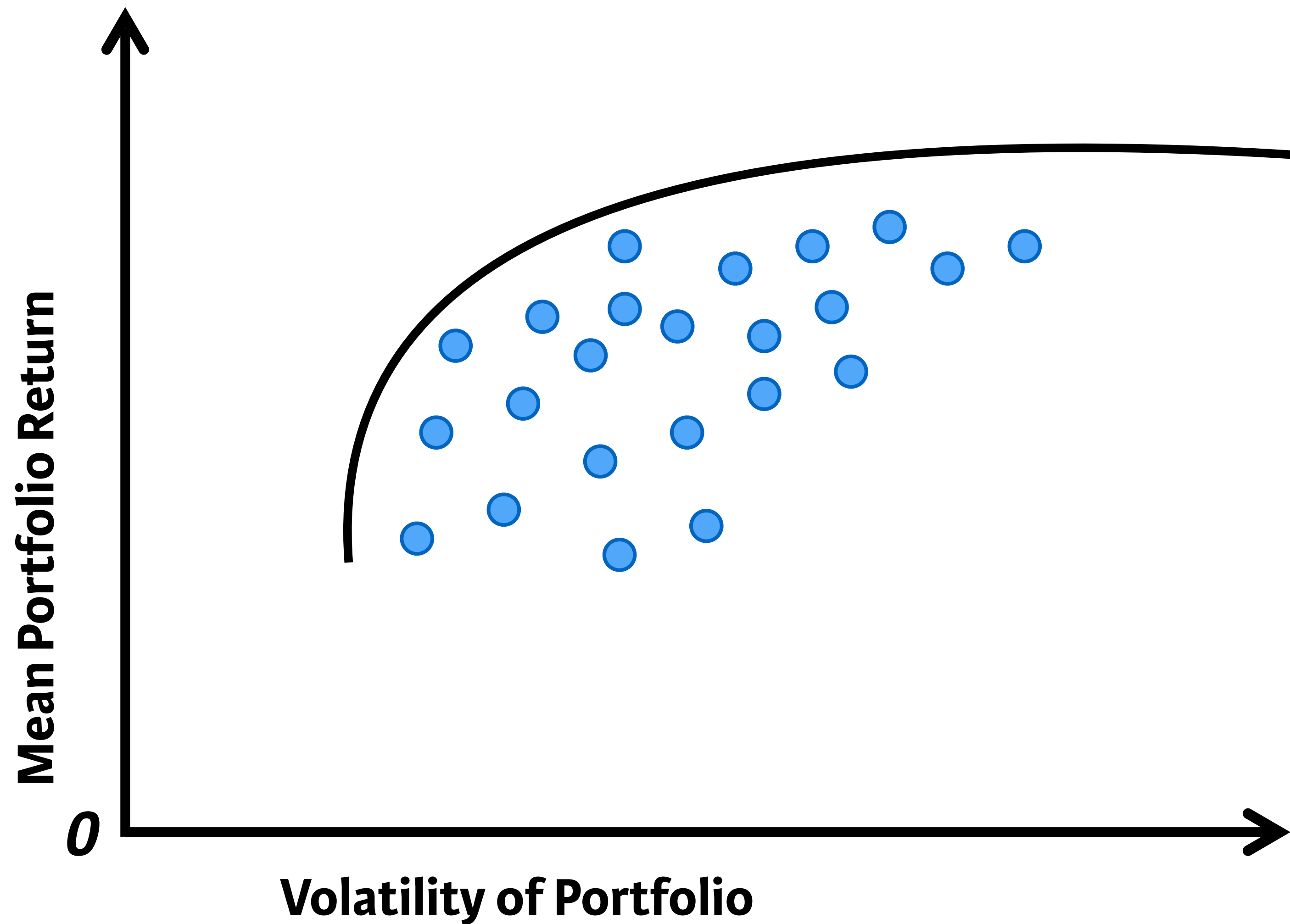
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The Efficient Frontier

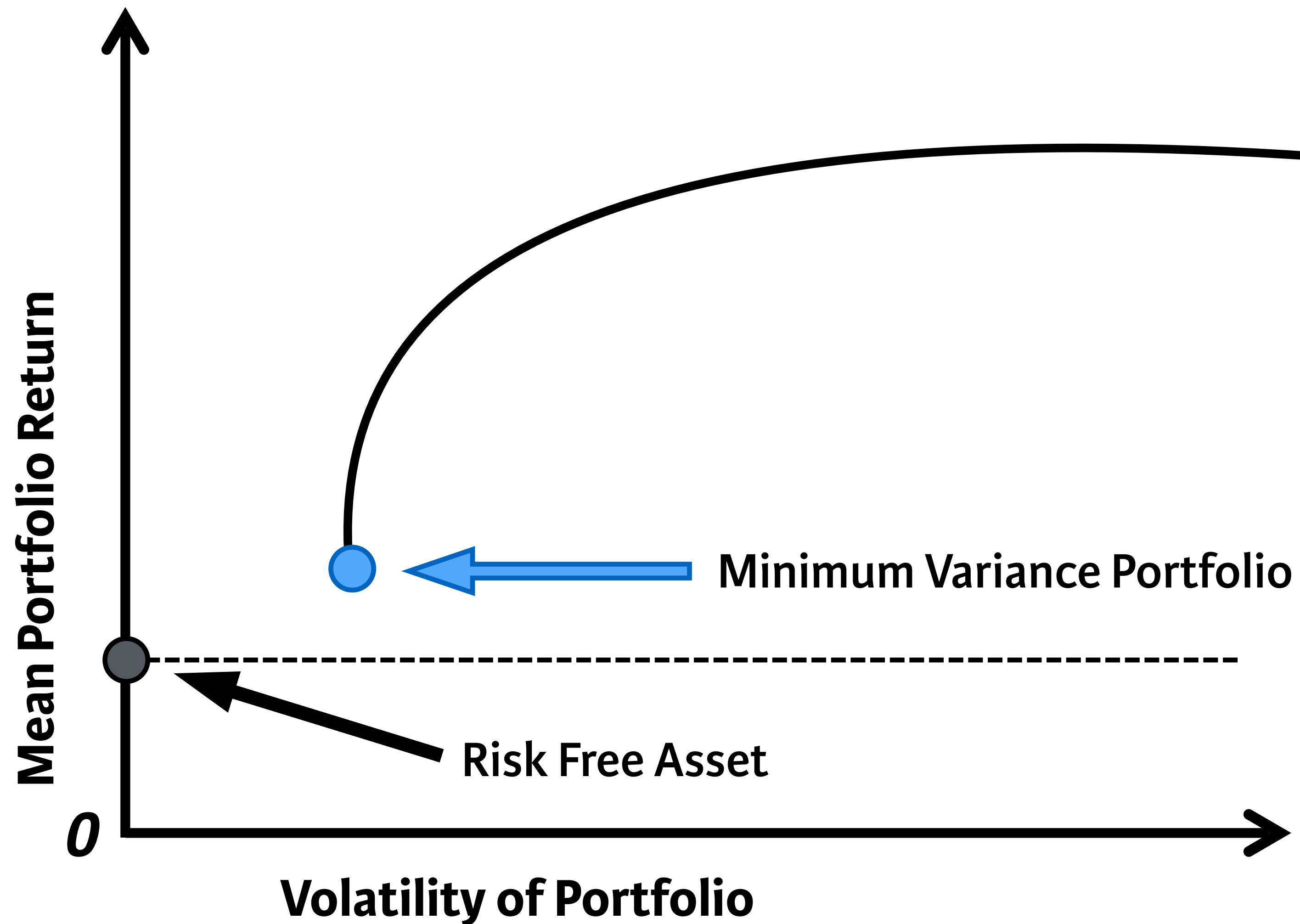
Changing Target Return



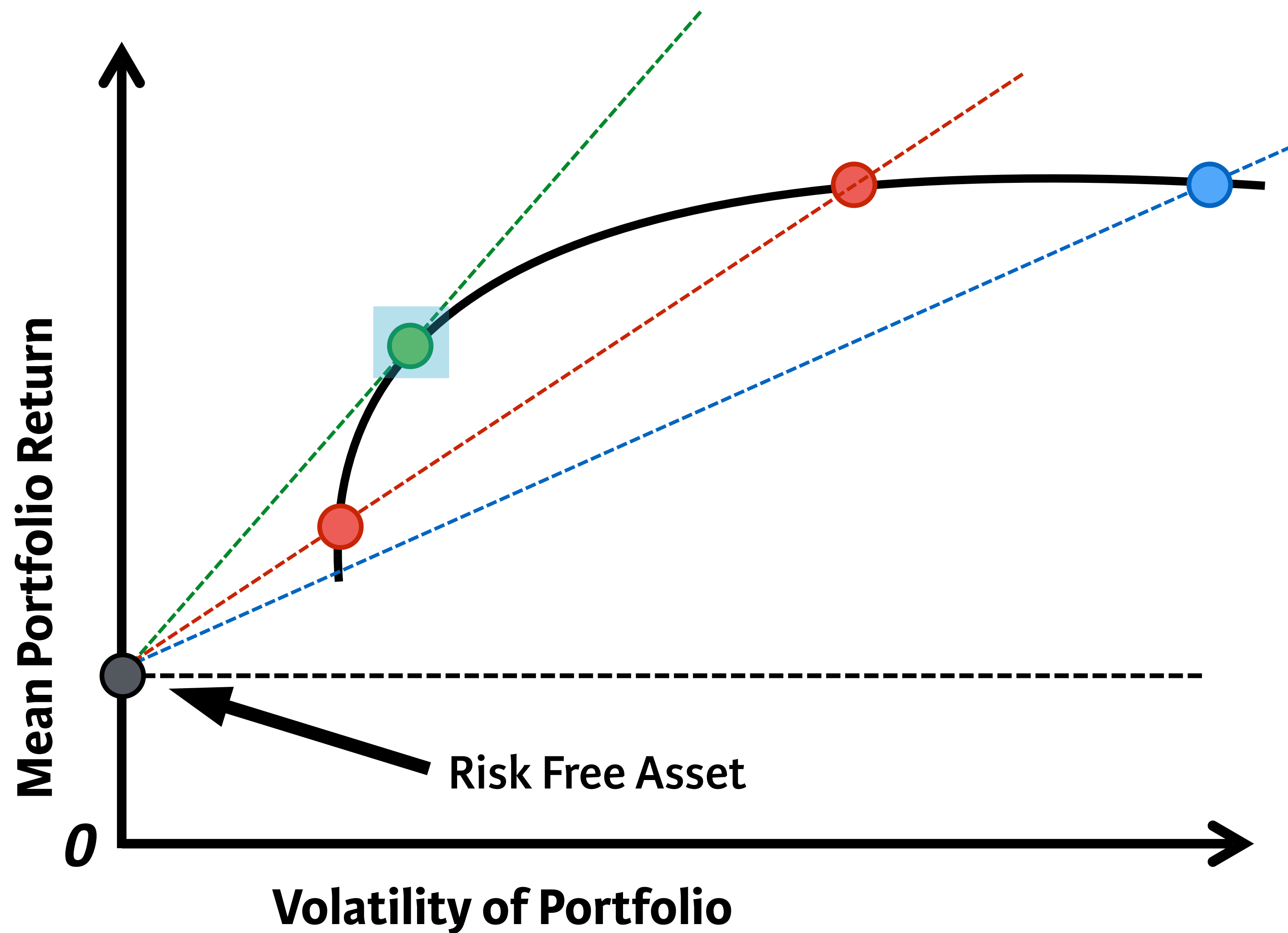
The Efficient Frontier



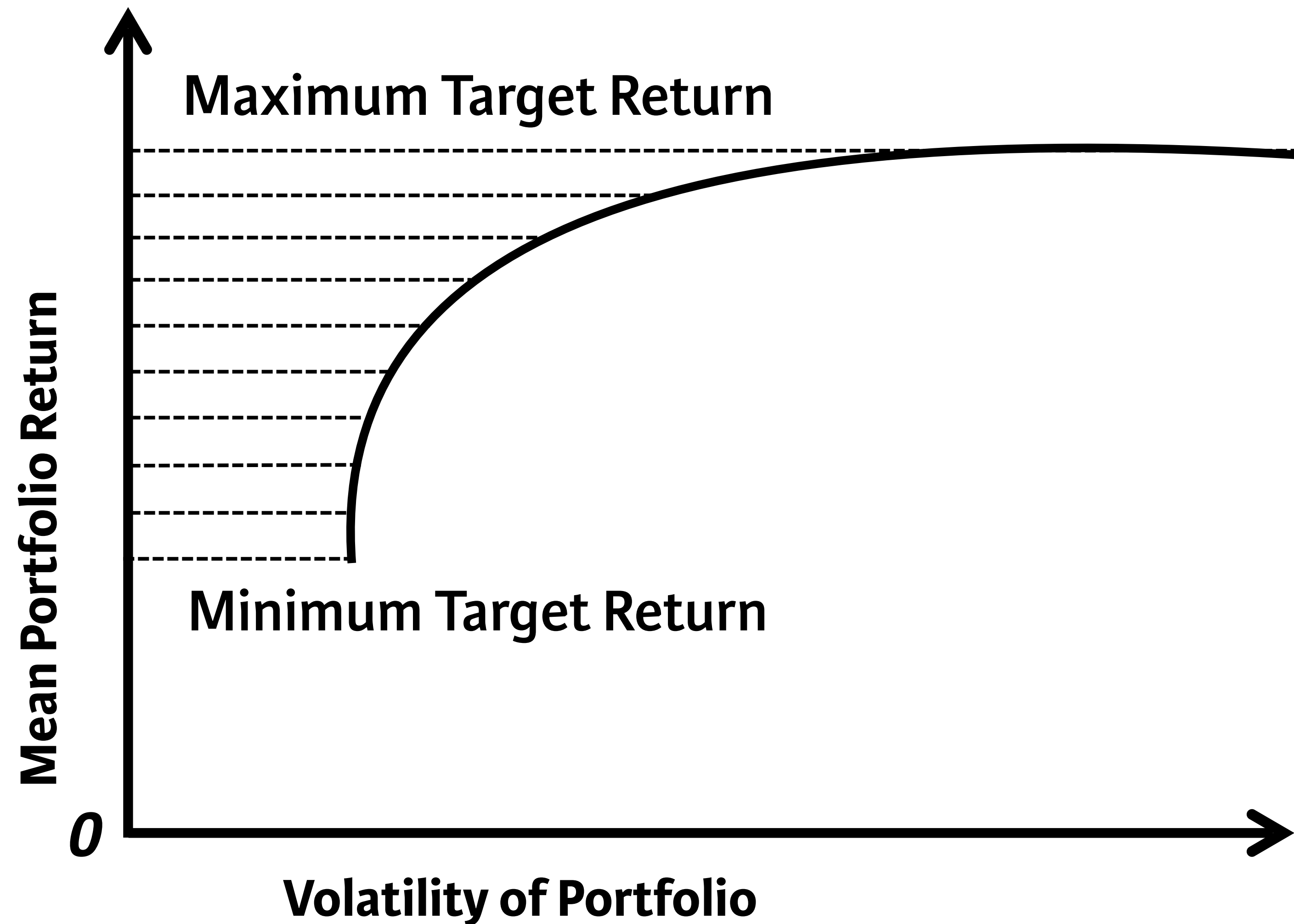
Minimum Variance Portfolio



Maximum Sharpe Ratio Portfolio



Time For Practice





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Let's practice!



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In-Sample vs. Out-of-Sample

Bad News: Estimation Error

- Limitation to data-driven portfolio allocation:

Use in Practice

Estimated mean $\hat{\mu}$

Estimated variance $\hat{\sigma}^2$

Optimized weights based on
estimated mean & variance: \hat{w}

Use In Theory

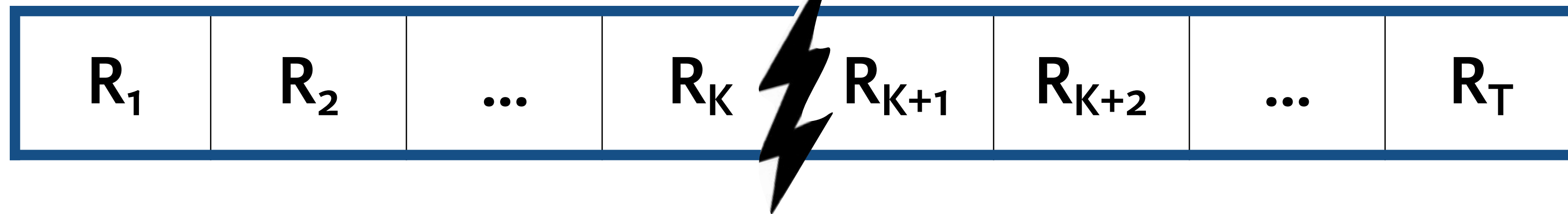
True (unknown) mean μ

True (unknown) variance σ^2

True optimal portfolio: w

Y

- Do not ignore estimation error
- Use split-sample analysis to do a realistic evaluation of portfolio performance

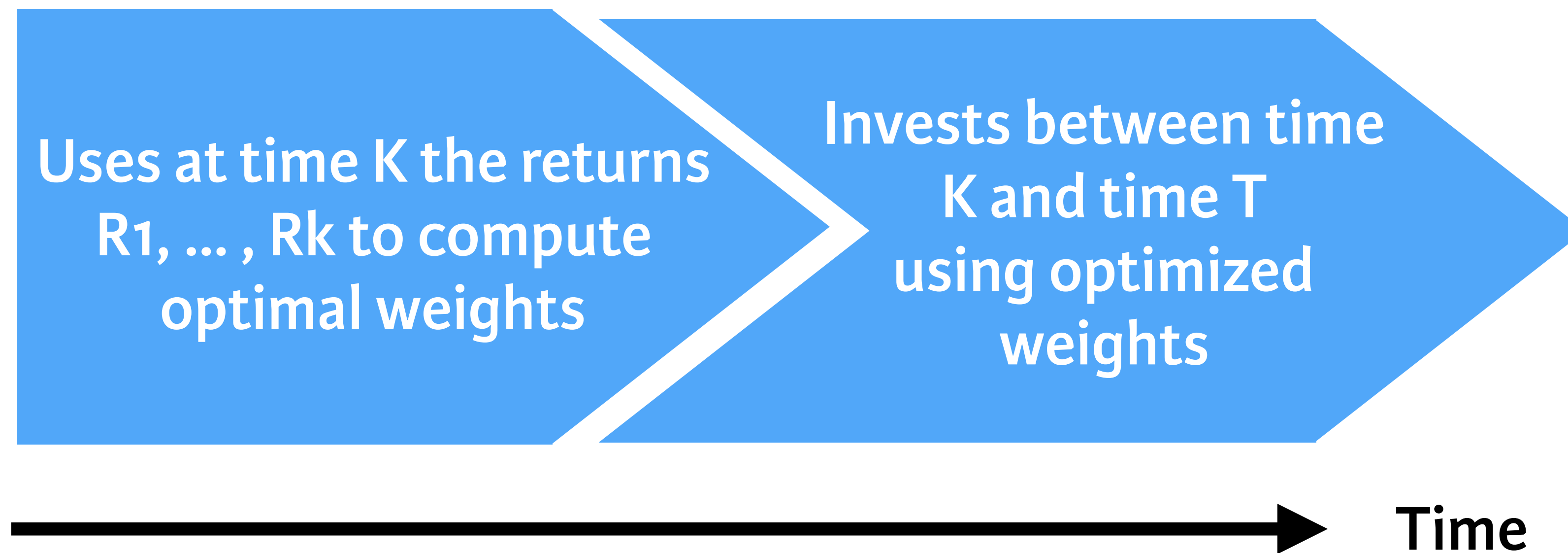


Estimation sample
used to find
the optimal weights

Out-of-Sample
evaluation to give a
realistic view on
portfolio performance

No Look-Ahead Bias In Optimized Weights

- Split-sample design matches with the investor who:



- Function `window()` to do split-sample analysis in R



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Let's practice!