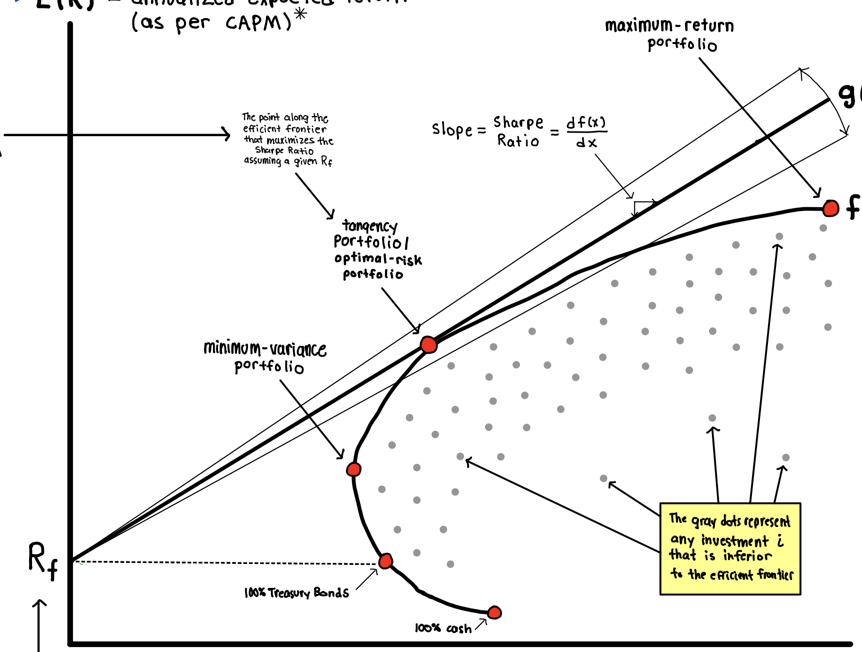
E(R) could be anything! It doesn't have to be CAPM...

CAPM (Capital Asset Pricing Model) + MV Optimization

E(R) = annualized expected return (as per CAPM)*

"The only port. that we should ever invest in!"



g(x) = CAL (Capital Allocation Line)
↳ Visualizes a linear tradeoff between risk & reward

f(x) = Efficient Frontier
↳ The boarder of the feasible set: $\int f(x)dx$
↳ Represents optimally-weighted portfolios
↳ Becomes more convex as per diversification

σ = annualized standard deviation of returns

Note: The y-intercept of CAL is FIXED at the risk-free rate of return R_f

*While the feasible set may be composed of realized returns, the frontier itself is an ESTIMATE i.e., always apply your E(R) equation - CAPM - to a fixed-width, linear series of hypothetical numbers.

$$\sigma_i = \sqrt{Var(E(R)_i)} = \sqrt{\frac{\sum_{i=1}^{n}\left(E(R)_i^{\frac{R-R_f}{R_f}} - \mu\right)^2}{n}}$$

Denotes standard deviation of $E(R)_i$ and is the conventional measure of TOTAL risk as per Modern Portfolio Theory

$$E(R)_i^{CAPM} = R_f + \beta_i\underbrace{(E(R)_{MARKET} - R_f)}_{\text{= the market's risk premium}}$$

This is your benchmark, It could be anything... The S&P500 w/ benchmark weights, the S&P500 w/ equal weights (i.e., the 1/n "naive" portfolio), etc.

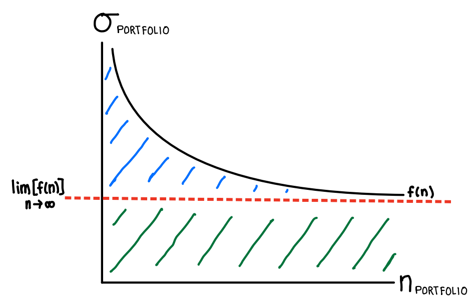
$$\beta_i = \frac{COV(E(R)_i^{\frac{R-R_f}{R_f}}, E(R)_{MARKET}^{\frac{R-R_f}{R_f}})}{\sigma^2_{E(R)_{MARKET}}} \Rightarrow \beta_i \begin{cases} i \text{ riskier than market} & >1 \\ i \text{ less risky than market} & <1 \end{cases}$$

beta measures the SYSTEMATIC risk attached to asset i (how much market risk is added to the portfolio by including i) = CORR(SPX, i)

The risk-free rate is conventionally representative of E(R) for government bonds i.e., U.S. Treasuries

Converts $E(R)_i^{\frac{R-R_f}{R_f}}$ = long-run average of absolute measure of expected return into a relative measure of expected return $E(R)_i^{CAPM}$

CAPM is widely used to establish the y-axis given β_i



$\underbrace{\int \lim_{n\to\infty}[f(n)]}_{\text{a constant \#}}$ = systematic risk aka market risk
- cannot be reduced via diversification
- can be reduced by Shorting S&P500 via E-mini

$\int f(n)dn - \underbrace{\int \lim_{n\to\infty}[f(n)]}_{\text{a constant \#}}$ = diversifiable risk aka idiosyncratic risk aka unsystematic risk

The constrained optimization problem becomes either:

1. maximize return for a given level of risk
2. minimize risk for a given expectation for return