

Charta Learning

Diversification, CAPM, Beta and the Sharpe Ratio

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Diversification

PM.2.a · Explain how correlation between assets changes the risk of a portfolio

What happens to portfolio risk when correlation is +1?	Portfolio standard deviation is just the weighted average, so there is no diversification benefit.
What can be achieved at a correlation of -1?	A weighting exists that eliminates volatility entirely.
Why can adding a volatile asset lower total portfolio risk?	A benefit exists whenever correlation is below +1, so a weakly correlated asset can reduce total risk.
Why is the correlation benefit less reliable in practice?	Correlations are unstable and tend to rise in crises, exactly when diversification is most needed.
Correlation from covariance	$\rho = \text{Cov} \div (\sigma_1 \times \sigma_2)$ where Cov = the covariance of the two returns; σ_1, σ_2 = the standard deviation of each return; ρ = the correlation, always between -1 and 1 Covariance says which way two assets move together but its size depends on the units. Dividing by both standard deviations scales that out, which is why correlation can be compared across pairs and covariance cannot.

PM.2.b · Set out what the minimum-variance frontier and the efficient frontier are

What does the minimum-variance frontier plot?	For each level of expected return, the portfolio with the lowest achievable variance.
What is the global minimum-variance portfolio and where is the efficient frontier?	The leftmost point of the minimum-variance frontier; the efficient frontier is the portion above it.
Why does no rational investor hold a portfolio below the efficient frontier?	Another portfolio exists with the same risk and higher expected return.
Why does the frontier curve, and what makes it bow further left?	Imperfect correlation generates diversification; lower correlations among assets bow it further left.

PM.2.c · Explain what adding a risk-free asset does, and the capital allocation line

Why can a risk-free asset be combined with any risky portfolio along a straight line?	It has zero variance and zero covariance with everything.
Which capital allocation line dominates and what is its slope?	The steepest, tangent to the efficient frontier. Its slope is the Sharpe ratio of the tangency portfolio.
What would investors with the same expectations and free borrowing and lending hold?	Some mix of the risk-free asset and the same tangency portfolio, varying only the proportions.

How do conservative and aggressive investors differ on this line?	Conservative: lend at the risk-free rate. Aggressive: borrow to move beyond the tangency point.
Capital allocation line	$E(R_p) = r_f + [(E(R_m) - r_f) \div \sigma_m] \times \sigma_p$ where r_f = the return on the risk-free asset; $E(R_m)$ = the expected return of the risky portfolio being combined with it; σ_m = the standard deviation of that risky portfolio; σ_p = the standard deviation of the combination; $E(R_p)$ = the expected return of the combination A straight line, because mixing with a risk-free asset has no correlation term to bend it. Left of the risky portfolio is lending at r_f , right of it is borrowing to buy more.
Sharpe ratio	$\text{Sharpe} = (R_p - r_f) \div \sigma_p$ where R_p = the portfolio's return; r_f = the risk-free rate; σ_p = the standard deviation of the portfolio's return Return earned per unit of total risk, and the slope of the capital allocation line drawn through that portfolio. The steepest line is the best one available, which is what picking the tangency portfolio means.

PM.2.d · Explain the market portfolio and the idea of two-fund separation

What are the two decisions in two-fund separation?	Which risky portfolio to hold, and how much of total wealth to place in it.
Which decision depends on risk aversion?	Only the second, how much wealth to place in the risky portfolio.
Why is the first answer the same for every investor?	With shared expectations and risk-free borrowing and lending, everyone's best risky portfolio is the tangency portfolio.
Why must the common risky portfolio be the market portfolio?	If all investors hold the same risky portfolio, in equilibrium it must be the market portfolio, taking the framework to the capital market line and the CAPM.

The Capital Asset Pricing Model

PM.4.a · Work out a required return with the capital asset pricing model

What is the CAPM formula for required return?	Required return = risk-free rate + beta × market risk premium.
Why does the CAPM reward only systematic risk?	Risk specific to one company can be diversified away at no cost, so no investor should be paid for bearing it.
What does beta measure?	Sensitivity to the market: one moves with it, above one amplifies it, below one damps it.
What lasting discipline does the CAPM impose?	It forces the question of whether a risk is one the market will pay you to hold.

Required return from the capital asset pricing model	required return = $r_f + \beta \times (\text{market return} - r_f)$ where r_f = the risk-free rate, usually a long government bond; β = the asset's sensitivity to the market; market return = the expected return on the market portfolio The return an asset must offer for the systematic risk it carries. Plotted against beta this is the security market line, and it prices only risk that cannot be diversified away - an asset with a beta of zero is required to return no more than the risk-free rate however volatile it is.
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PM.4.b · Tell apart systematic risk and nonsystematic risk

What is systematic risk, and why can it not be diversified away?	Exposure common to the whole market (rates, growth, inflation, policy); every asset carries some of it.
What is nonsystematic risk and what happens to it as holdings are added?	Risk specific to a company or industry; it falls rapidly as holdings are added, approaching negligible in a broad portfolio.
Why does bearing nonsystematic risk earn no premium?	Anyone could eliminate it at no cost by diversifying, so investors are compensated only for risk they cannot avoid.

PM.4.c · Work out beta and explain what it means

How is beta defined?	The covariance of the asset's return with the market's, divided by the market's variance.
What is the alternative expression for beta using correlation?	Beta = correlation with the market $\times$ (asset standard deviation $\div$ market standard deviation).
What do betas of one, above one and below one mean?	One: moved with the market on average. Above one: amplified moves. Below one: damped moves.
How is a portfolio's beta found, and why does that matter?	It is the weighted average of its holdings' betas, making beta the practical tool for managing market exposure at portfolio level.
Beta	$\beta = \text{Cov} \div \text{market variance}$ where Cov = the covariance of the asset's return with the market's; market variance = the variance of the market's return How much of the market's move the asset takes. The market has a beta of one by construction, and a beta above one means the asset amplifies the market rather than that it is more volatile in any absolute sense.

PM.4.d · Apply the security market line to spot assets that are mispriced

What does the security market line plot?	Required return against beta; under the CAPM every correctly priced asset lies on it.
How do you judge an asset whose expected return plots above or below the line?	Above: undervalued, as it offers more than its systematic risk warrants. Below: overvalued.

What is alpha in this context?	The vertical distance between an asset's expected return and the security market line.
Why should a plot far above the line be treated with caution?	The test is only as good as the expected return estimate, so the forecast is more likely wrong than the market leaving money on the table.
Alpha against the security market line	α = expected return – required return where expected return = the return the analyst forecasts for the asset; required return = what the capital asset pricing model says it should return for its beta; α = the difference between them Positive alpha plots above the security market line and the asset is underpriced; negative plots below and it is overpriced. It is only ever as good as the forecast, which is why two analysts get two alphas for the same share.

PM.4.e · Explain where the capital asset pricing model falls short

Which assumptions of the CAPM do not hold in practice?	A single period, homogeneous expectations, unlimited borrowing and lending at the risk-free rate, no taxes or transaction costs, and a market portfolio containing every asset.
What is Roll's critique?	The true market portfolio, including human capital and private assets, is unobservable, so any CAPM test is a joint test of the model and the market proxy.
What empirical evidence challenges beta as the sole explanation of returns?	Size, value and momentum have explained returns beyond beta.
What did that evidence motivate?	The multifactor models that followed.

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