

Charta Learning

Time Value of Money, NPV, IRR and Hypothesis Tests

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Time Value of Money

QM.1.a · Work out what a cash flow will be worth in future

What is the future value formula for a single cash flow?	$FV = PV \times (1 + r)^n$, where r is the rate per period and n the number of periods.
Why is the relationship exponential rather than linear?	Compounding means interest earns interest.
How do you adjust when compounding is more often than annual?	Divide the stated annual rate by periods per year and multiply the years by the same figure.
What two habits prevent most errors?	Keep the rate and the period on the same time basis, and draw a timeline before touching a formula.
Future value of a single cash flow	$FV = PV \times (1 + r)^n$ where PV = the amount invested today; r = the rate per compounding period, not per year; n = the number of compounding periods, not years r and n must be on the same footing. A 6% annual rate compounded quarterly is $r = 1.5\%$ and $n = 4$ per year, not $r = 6\%$ and $n = 1$.

QM.1.b · Work out what one cash flow is worth today

What is the present value formula?	$PV = FV \div (1 + r)^n$.
What does the discount rate represent?	The return available on an equivalent alternative; discounting asks what sum today would grow into the promised amount.
How do rate and number of periods affect present value?	Both push the same way: a higher rate or a longer wait means a smaller present value.
Why is discounting called the single operation underneath valuation?	Bond pricing, NPV and every valuation model reduce to discounting future amounts and adding them up.
Present value of a single cash flow	$PV = FV \div (1 + r)^n$ where FV = the amount received at the end; r = the discount rate per period; n = periods until it is received The same relationship as future value, read backwards. Raising the rate or the horizon lowers the present value.

QM.1.c · Work out what an annuity and a perpetuity are worth today

What is the difference between an annuity and a perpetuity?	An annuity is a fixed payment for a fixed number of periods; a perpetuity is the same payment forever.
What is the perpetuity formula?	$PV = PMT \div r$.

How is the ordinary annuity formula derived from the perpetuity?	The perpetuity less the perpetuity not received after the final payment: $PV = PMT \times [1 - (1 + r)^{-n}] \div r$.
How does an annuity due differ in value from an ordinary annuity?	It pays at the start of each period, so each payment is discounted one period less: value = ordinary annuity $\times (1 + r)$.
Present value of a perpetuity	$PV = PMT \div r$ where PMT = the level payment, received for ever; r = the rate per period Level payments with no end date, first payment one period from now. A perpetuity due is worth this $\times (1 + r)$.
Present value of an ordinary annuity	$PV = PMT \times [1 - (1 + r)^{-n}] \div r$ where PMT = the level payment each period; r = the rate per period; n = the number of payments Payments at the END of each period. For an annuity due, multiply by $(1 + r)$.

QM.1.d · Contrast a stated annual rate with the effective annual rate

Why is a stated annual rate uninformative on its own?	It means nothing until the compounding frequency is attached.
What is the EAR formula?	$EAR = (1 + \text{stated} \div m)^m - 1$, where m is the number of compounding periods.
What happens to EAR as compounding becomes continuous?	It rises with frequency, approaching e raised to the stated rate, minus 1.
Why convert quoted rates to EARs before comparing them?	Rates with different compounding frequencies are not comparable until expressed as EARs.
Effective annual rate from a stated rate	$EAR = (1 + \text{stated} \div m)^m - 1$ where stated = the quoted, or nominal, annual rate; m = compounding periods a year Comparing two quoted rates with different compounding frequencies. Quoted rates are not comparable until both are EARs.
Effective annual rate under continuous compounding	$EAR = e^r - 1$ where r = the stated annual rate; e = 2.7183, the base of natural logarithms The ceiling that more frequent compounding approaches. Daily compounding is already within a basis point of it.

Discounted Cash Flow

QM.3.a · Work out net present value and the internal rate of return

What does a positive NPV mean?	The project adds value at the required return; NPV discounts every cash flow at that return and subtracts the outlay.
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What is the internal rate of return?	The discount rate that sets NPV to zero; it answers at what rate rather than how much value.
When can NPV and IRR disagree?	On ranking two projects; they agree on accept-or-reject for a single conventional project.
Why does IRR have a limitation as a proxy for realised return?	It is only a good proxy if interim cash flows can be reinvested at the IRR itself.
Which criterion should be followed when NPV and IRR conflict, and why?	NPV: it is the preferred value-maximising criterion and is denominated in money, which is what shareholders receive.
Net present value	$NPV = \sum CF_t \div (1 + r)^t$ where CF_t = the cash flow at time t , with the initial outlay as a negative CF_0 ; r = the required rate of return; t = the period, counted from 0 Accept if NPV is positive. Where NPV and IRR disagree on mutually exclusive projects, NPV wins.

QM.3.b · Work out a holding period return and explain what it means

What is the holding period return formula?	$HPR = (\text{ending value} - \text{beginning value} + \text{income}) \div \text{beginning value}.$
What does holding period return include?	Both the price change and any income received.
What assumptions does it avoid?	None about the length of the period and no adjustment for reinvestment, making it the raw building block for other return measures.
How is a multi-period return built from holding period returns?	By chaining them geometrically.
Holding period return	$HPR = (P_1 - P_0 + D_1) \div P_0$ where P_0 = the price at the start; P_1 = the price at the end; D_1 = any cash received over the period One period, any length. It is not annualised, and annualising a short one magnifies the noise in it.

QM.3.c · Contrast money-weighted with time-weighted rates of return

What is a money-weighted return?	The internal rate of return of the portfolio's cash flows, so it is affected by when money was added or withdrawn.
What is a time-weighted return?	Chaining the returns of each sub-period, unaffected by flows.
Why is time-weighted return the fair basis for judging a manager?	The manager does not control deposits and withdrawals; it is also what performance standards require.
What does the money-weighted return capture that time-weighted does not?	The investor's own experience: having money invested when returns were good.

Time-weighted rate of return	time-weighted return = $(1 + r_1) \times (1 + r_2) - 1$ where r_1, r_2 = the holding period return of each sub-period, cut at every external cash flow The manager's return, because breaking the period at each deposit and withdrawal removes the effect of when the client added money. The money-weighted return is an internal rate of return and does include it, which is why it is the client's return rather than the manager's.
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QM.3.d · Work out the various yields quoted on money market instruments

Why must money market yields be converted before comparing?	Short-dated instruments are quoted on conventions that are not comparable without conversion.
What is the bank discount yield and why does it understate return?	The discount as a fraction of face value, annualised on 360 days; the investor pays less than face.
What is holding period yield?	The return using the price actually paid.
How do the effective annual yield and money market yield differ?	Effective annual yield compounds the holding period yield over the year; money market yield annualises it on 360 days without compounding.
Bank discount yield	$BDY = (D \div F) \times (360 \div t)$ where D = the discount from face value; F = the FACE value, not the price paid; t = days to maturity The quoting convention for T-bills, and it understates the true return twice over: it divides by face rather than price, and it does not compound.
Effective annual yield	$EAY = (1 + HPY)^{(365 \div t)} - 1$ where HPY = the holding period yield over the t days; t = days held The one money-market yield that both compounds and uses a 365-day year. It is the honest comparison.
Money market yield	$MMY = HPY \times (360 \div t)$ where HPY = the holding period yield; t = days held Annualises on price rather than face, which fixes the bank discount yield's first error but not its second: it still does not compound.

Hypothesis Testing

QM.7.a · Set up the null and the alternative hypothesis

What defines the null hypothesis?	It is the statement being tested and always contains the equality; it is held until the evidence is strong enough to abandon it.
When does the analyst conclude the alternative hypothesis?	Only if the null is rejected; the alternative is what the analyst suspects.

What is the difference between a one-tailed and a two-tailed test?	One-tailed asks whether a parameter is greater, or smaller, than a value; two-tailed asks only whether it differs.
Why must the tail direction be chosen before seeing the data?	Picking the tail that suits the result turns the test into a formality.
What does failing to reject the null tell you?	It is not proof that the null is true.

QM.7.b · Explain what a p-value means and the two kinds of testing error

What does a p-value measure?	The probability of a result at least as extreme as the one obtained, if the null hypothesis were true.
What does a p-value not tell you?	It is not the probability that the null is true, and it says nothing about how large or important an effect is.
Define Type I and Type II errors.	Type I rejects a true null (its probability is the chosen significance level); Type II fails to reject a false null.
Why is choosing the significance level a judgement, not a default?	Tightening it reduces Type I errors but increases Type II errors, so it depends on which mistake costs more.

QM.7.c · Choose the right test for a hypothesis concerning a mean

When does a z-test apply to a mean?	When the population variance is known and the population is normal.
When is a t-test used for a mean, and with what degrees of freedom?	When variance is unknown (the usual case), using the sample standard deviation and $n - 1$ degrees of freedom.
Why does the choice matter less for large samples?	The t distribution approaches the normal, so the two tests converge.
How do tests differ for two independent samples versus paired observations?	Independent samples use a two-sample t-test; paired observations (such as the same portfolios before and after a change) use a paired test on the differences.
Test statistic for a hypothesis about a mean	$t = (\bar{x} - \mu_0) \div (s \div \sqrt{n})$ where $\bar{x}$ = the sample mean; μ_0 = the mean the null hypothesis asserts; s = the sample standard deviation; n = the sample size The t-distribution when the population standard deviation is unknown, which is almost always. The denominator is the standard error, so the statistic is the distance from the hypothesis measured in standard errors, with $n - 1$ degrees of freedom.

QM.7.d · Explain how a correlation coefficient is tested

Why must a sample correlation be tested?	It can be non-zero purely by chance, so a test is needed before concluding the variables are related.
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What are the null and the test statistic when testing a correlation?	The null is that the population correlation is zero; the statistic follows a t distribution with $n - 2$ degrees of freedom.
Why can a weak correlation be significant while a strong one is not?	The statistic rises with both the correlation and the sample size, so a large sample can make a weak correlation significant and a small one a strong one insignificant.
What does significance of a correlation not show?	It shows whether a relationship exists, never whether it is large enough to act on.
Test statistic for a correlation coefficient	$t = r \times \sqrt{(n - 2) \div (1 - r^2)}$ where r = the sample correlation; n = the number of paired observations Tests whether a correlation differs from zero, with $n - 2$ degrees of freedom. A small correlation becomes significant on a large enough sample, which is why significance and importance are not the same finding.

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