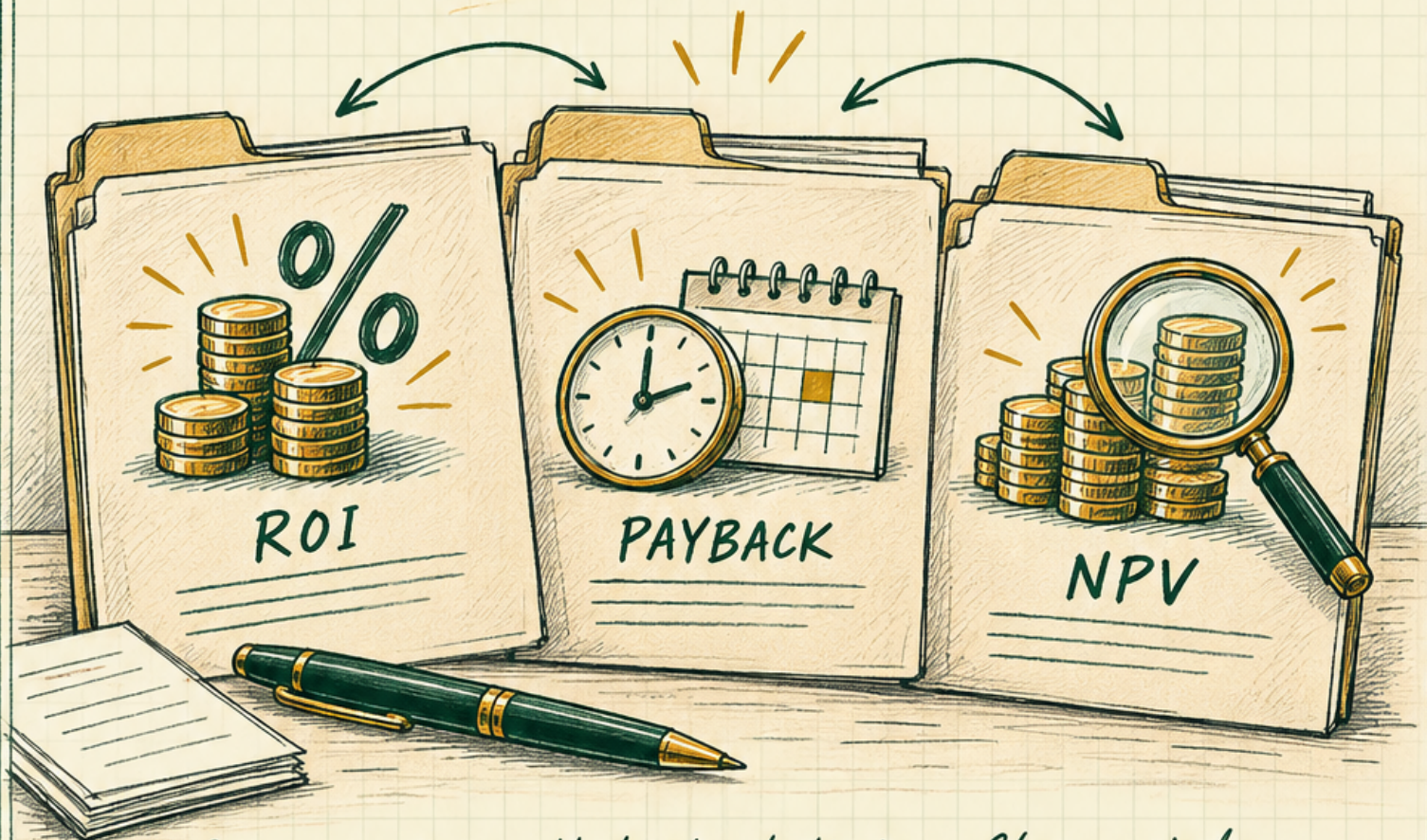


PROJECT SELECTION CALCULATIONS

ROI, Payback Period,
and NPV

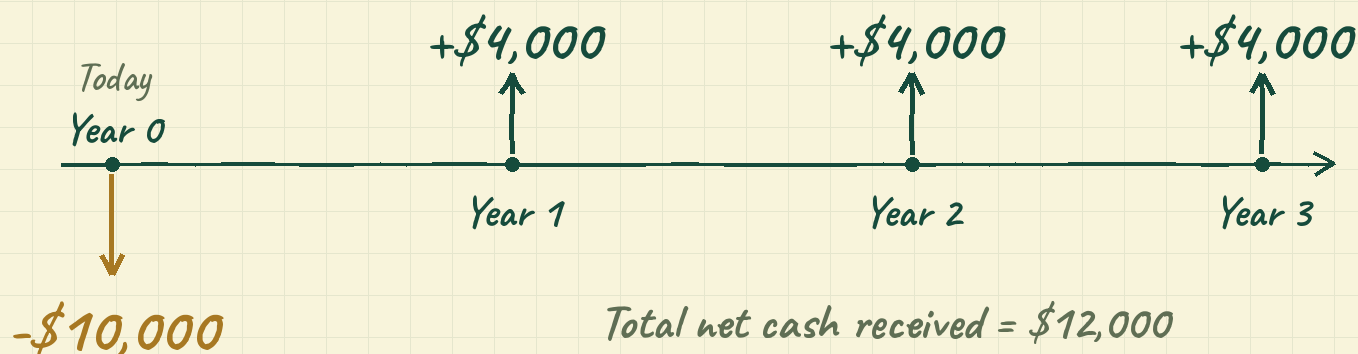


Compare returns. Understand timing. Choose wisely.

One investment. Three answers.

Use ROI, payback and NPV to ask different questions.

Invest \$10,000 today. Receive \$4,000 of net cash at each year-end for 3 years. No other cash flows. Required return: 10% a year.



① ROI / How much net gain?

$$ROI = (\text{Net gain} \div \text{Initial investment}) \times 100$$

$$(\$12,000 - \$10,000) \div \$10,000 \times 100 = 20\%$$

This is simple cash-based ROI over the full 3-year period. It is not a 20% annual return.

② PAYBACK / When is the cost recovered?

After Year 1: \$6,000 unrecovered. After Year 2: \$2,000.

Year 3 recovers the balance. Payback = 3 years.

Cash arrives at year-end in this example. Simple payback ignores discounting.

③ NPV / What is the project worth today?

Discount each future cash flow at 10% per year:

$$NPV = -10,000 + \frac{4,000}{1.10} + \frac{4,000}{1.10^2} + \frac{4,000}{1.10^3}$$

$$NPV = -\$52.59$$

Present value of inflows: \$9,947.41, below the \$10,000 outlay.

READ THE RESULTS TOGETHER

A positive simple ROI can still have a negative NPV. These cash flows fall short of the 10% required return.

Build the cash-flow model first

Compare the project with the realistic alternative of not doing it.

1 Define the baseline, horizon and timing

Record incremental cash receipts and payments, including setup, operations, working capital and disposal. Specify when each occurs and how long the analysis lasts.

$$\text{Incremental cash flow} = \text{Cash with project} - \text{Cash without project}$$

Include an opportunity cost when the project uses an asset or resource that could earn cash elsewhere. Exclude money already spent that cannot change with this decision.

2 Worked example: the initial outlay

Cash item at time 0	Amount	Include?
New equipment	\$10,000	Yes
New setup and training	\$2,000	Yes
Extra working capital	\$3,000	Yes
Research already paid	\$1,500	No: sunk cost

$$\text{Initial outlay } I = \$10,000 + \$2,000 + \$3,000 = \$15,000$$

The historical research payment does not change the go/no-go decision.

3 Keep cash, profit and funding consistent

Depreciation is not itself a cash payment, but related tax effects may change cash flow. Use relevant tax payment dates and distinguish cash forecasts from accounting profit.

When discounting project cash flows at a rate that already includes financing costs, avoid deducting interest again. Do not deduct operating costs twice if the forecast already gives net cash inflows.

Simple ROI: define the calculation

This handbook uses cash gain relative to the initial investment.

1 State the convention and the full period

$$\text{Net cash gain} = \text{Total net cash received} - \text{Initial outlay } I$$

$$\text{Simple ROI} = (\text{Net cash gain} \div I) \times 100$$

Here, future receipts are already net of relevant operating cash payments. Use all cash flows within the stated project horizon. This simple measure does not discount them.

Other ROI definitions use accounting profit or total costs. Label your convention.

2 Worked example: a three-year project

Input	Value
Initial investment	\$15,000 at time 0
Net cash inflow	\$6,500 at each of 3 year-ends
Other cash flows	None in this model

$$\text{Total receipts} = 3 \times \$6,500 = \$19,500$$

$$\text{Net cash gain} = \$19,500 - \$15,000 = \$4,500$$

$$\text{ROI} = \$4,500 \div \$15,000 \times 100 = 30\%$$

30% is the simple return across all three years, not per year.

3 Read the result within its limits

A positive ROI means total modeled receipts exceed the initial investment under this convention. It does not show whether the receipts arrive soon enough to meet the required return.

Do not compare this cash-based ROI directly with an accounting return or an annual interest rate. ROI is also different from IRR, the discount rate that makes NPV zero.

A higher ROI may add less value

Compare project size, timing and the definition of return.

1 Look at percentages and money together

ROI measures gain relative to an investment. NPV measures value in money at a stated discount rate. A small project can have the higher percentage while creating less total value.

Before ranking alternatives, align the cost boundary, useful life, cash-flow dates and currency. A 30% total return over one year is not directly comparable with 30% over five years.

2 Worked example: two one-year alternatives

Measure	Project A	Project B
Initial investment	\$2,000	\$10,000
Receipt at Year 1 end	\$3,000	\$13,000
Undiscounted net gain	\$1,000	\$3,000
Simple ROI	50%	30%

At 10%: $NPV(A) = \$3,000 \div 1.10 - \$2,000 = \$727.27$

At 10%: $NPV(B) = \$13,000 \div 1.10 - \$10,000 = \$1,818.18$

A has the higher ROI. B has the higher NPV.

3 Use the decision constraints

If only one project can be chosen, both are feasible, and the aim is to maximize financial value, B is better under these assumptions. It also needs \$8,000 more initial funding.

A capital limit, scarce specialist or strategic requirement may change the feasible choice. Show those constraints explicitly instead of assuming the largest ROI always wins.

Payback with regular cash receipts

Recovery time depends on when usable cash actually arrives.

① Use the shortcut only with matching timing

$$\text{Payback} = \text{Initial investment} \div \text{Net cash received per period}$$

This shortcut works for a constant flow with an appropriate timing assumption. If recovery falls between scheduled payments, use the actual receipt dates or clearly state an interpolation assumption.

Payback measures recovery of the initial outlay; it is not a profitability ratio.

② Worked example: equal monthly receipts

Invest \$12,000 now and receive \$400 at the end of every month. No other cash flows occur in this example.

$$\text{Payback} = \$12,000 \div \$400 = 30 \text{ months}$$

$$30 \text{ months} \div 12 = 2.5 \text{ years}$$

If instead the same \$4,800 annual total arrived only at each year-end, two receipts would total \$9,600 and three would total \$14,400.

Monthly receipts: 2.5 years. Year-end-only receipts: end of Year 3.

③ Do not use payback as the whole decision

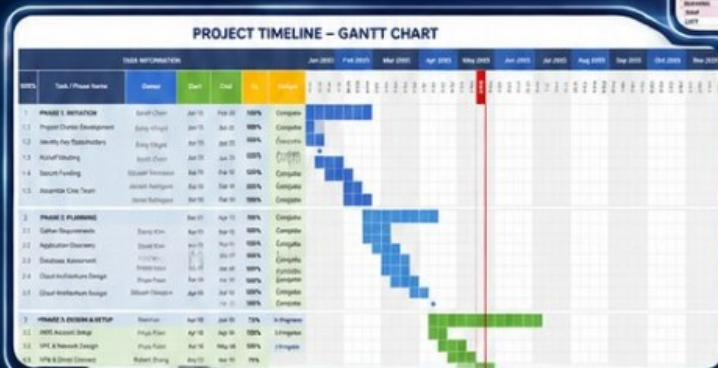
Simple payback ignores discounting and cash flows after recovery. A project with fast recovery can still create less value than a slower alternative.

An organization may set a maximum acceptable recovery time for liquidity or policy reasons. Treat that threshold as an explicit constraint, not as proof of positive NPV.

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Payback with uneven cash flows

Accumulate the receipts until the initial investment is recovered.

1 Track the remaining balance

$$\text{Unrecovered balance} = \text{Initial outlay} - \text{Cumulative net receipts}$$

Start at time 0, add each net cash flow in date order, and find the first point at which the cumulative project balance reaches zero. Retain the actual timing assumptions.

2 Worked example: an \$18,000 investment

Year-end	Net inflow	Cumulative project balance
0	-\$18,000	-\$18,000
1	+\$5,000	-\$13,000
2	+\$7,000	-\$6,000
3	+\$10,000	+\$4,000

With the stated year-end receipts: Payback = 3 years

If Year 3 cash instead arrives evenly throughout that year, an interpolated estimate is:

$$2 + (\$6,000 \div \$10,000) = 2.6 \text{ years}$$

The 2.6-year estimate requires a different within-year timing assumption.

3 Check the entire project horizon

If the balance never reaches zero, report that the project does not pay back within the modeled horizon. Do not invent receipts beyond the forecast.

Later maintenance, replacement or closure payments can reduce the balance again after initial recovery. Review all cash flows, not only the first crossing of zero.

Discounted payback may never occur

First discount the cash flows, then test cumulative recovery.

1 Allow for the required return

$$\text{Present value at time } 0 = \text{Cash flow at } t \div (1 + r)^t$$

Here r is the discount rate per period, and t is the number of periods from today. Discounted payback occurs when cumulative discounted receipts recover the initial outlay.

The symbol $^$ means “raised to the power of.” Keep periods and rates consistent.

2 Worked example: revisit the first page

Initial outlay = \$10,000. Three year-end receipts of \$4,000. Annual discount rate = 10%.

Year	Discounted receipt	Cumulative discounted receipts
1	\$3,636.36	\$3,636.36
2	\$3,305.79	\$6,942.15
3	\$3,005.26	\$9,947.41

$$\text{Unrecovered present value} = \$10,000 - \$9,947.41 = \$52.59$$

Simple payback: 3 years. Discounted payback: not reached in 3 years.

3 Interpret the failure to recover

The cash total exceeds \$10,000, but its discounted value does not. This is consistent with the negative NPV on page 1 at the same 10% rate.

Discounted payback still ignores later cash flows once recovery occurs. Use NPV alongside it, and do not treat an assumed additional operating year as an existing forecast.

Time value of money: move to one date

A dated cash flow must be translated before it can be compared.

1 Discount backward or compound forward

$Present\ value\ PV = Future\ cash\ flow \div (1 + r)^t$

$Future\ value\ FV = Present\ amount \times (1 + r)^t$

At a positive required return, a fixed future receipt is worth less today. Discounting is a valuation calculation; it is not a fee physically removed from the receipt.

2 Worked example: the same value at different dates

Cash receipt	Date	Present value at 10%
\$1,100	End of Year 1	$\$1,100 \div 1.10 = \$1,000$
\$1,210	End of Year 2	$\$1,210 \div 1.10^2 = \$1,000$
\$10,000	End of Year 2	$\$10,000 \div 1.10^2 = \$8,264.46$

Check: $\$1,000 \times 1.10^2 = \$1,210$

A time-0 cash flow is not discounted: $(1 + r)^0 = 1$.

3 Keep signs and precision

Use negative numbers for outflows and positive numbers for inflows. Convert all cash flows to the same valuation date before adding them.

Keep full precision while calculating discount factors and totals, then round the final answer. Rounding each intermediate line can produce small apparent differences.

NPV with equal annual cash flows

Use an annuity factor when amounts and intervals are constant.

1 Use the ordinary-annuity formula

$$PV\ factor = [1 - (1 + r)^{-n}] \div r$$

$$NPV = -Initial\ outlay + Annual\ net\ cash\ flow \times PV\ factor$$

This form assumes n equal end-of-period cash flows and a constant rate r. When r = 0, the factor is simply n. An immediate first receipt needs different timing.

2 Worked example: four annual receipts

Input	Value
Initial investment	\$20,000 now
Net inflow each year	\$8,000 at each year-end
Number of years	4
Annual required return	10%

$$PV\ factor = [1 - 1.10^{-4}] \div 0.10 = 3.169865...$$

$$NPV = -\$20,000 + \$8,000 \times 3.169865...$$

$$NPV = +\$5,358.92$$

3 Explain the answer

The discounted inflows are worth \$25,358.92 today. After the \$20,000 outlay, the model adds \$5,358.92 of value at the stated required return.

Positive NPV indicates financial value under the assumptions. Confirm that the investment is feasible, the forecast is credible and the project fits the organization's objectives.

NPV with uneven cash flows

Discount each dated amount separately before adding the values.

1 Use the general formula

$$NPV = CFO + CF1/(1+r) + CF2/(1+r)^2 + ...$$

CFO is the net cash flow today. Each later CF is the net inflow or outflow at its stated period-end. Keep zero-flow periods in the timeline.

The initial investment is usually negative; later net cash flows can also be negative.

2 Worked example: four different receipts

Invest \$15,000 at time 0. Use a 10% annual discount rate.

Year	Net cash flow	Present value
1	\$3,000	\$2,727.27
2	\$6,000	\$4,958.68
3	\$9,000	\$6,761.83
4	\$2,000	\$1,366.03

$$PV \text{ of inflows} = \$15,813.81$$

$$NPV = -\$15,000 + \$15,813.81 = +\$813.81$$

Do not replace these dated amounts with an average annual receipt.

3 Apply a financial decision rule

NPV above zero adds value at the selected rate; NPV below zero falls short. An NPV of zero means the model exactly meets that required return, not that cash receipts equal the original outlay.

These rules describe the financial model. Mandatory work, strategic benefits, forecast risk and resource constraints still need a documented decision.

Match the rate to the cash flows

Annual, monthly, nominal and real rates are different inputs.

1 Choose a consistent valuation basis

Use a required return appropriate to the project's risk and cash-flow basis. Do not choose a rate simply to make NPV positive. State whether the rate is effective or a quoted nominal annual rate.

Effective monthly rate = $(1 + \text{Effective annual rate})^{(1/12)} - 1$

Match after-tax cash flows with a compatible after-tax rate. Keep the currency and valuation date consistent across alternatives.

2 Worked examples: periods and compounding

Given rate	Monthly equivalent	Annual effective rate
12% effective annual	$1.12^{(1/12)} - 1$	12.00%
12% nominal annual, compounded monthly	$12\% \div 12 = 1\%$	$1.01^{12} - 1 = 12.6825\%$

12% effective annually = about 0.948879% per month

Dividing an effective annual rate by 12 is not an exact conversion.

3 Match inflation assumptions too

$1 + \text{Nominal rate} = (1 + \text{Real rate}) \times (1 + \text{Inflation})$

Real 5% and inflation 3%: $\text{Nominal rate} = 1.05 \times 1.03 - 1 = 8.15\%$

Discount inflation-adjusted future money amounts with a nominal rate, or constant-purchasing-power cash flows with a real rate. Here “nominal” describes inflation treatment, not the compounding convention above.

Include the cash released at the end

Working capital, disposal proceeds and closure costs affect NPV.

1 Use cash changes and actual dates

Additional working capital ties up cash when invested. Include its recoverable amount when released. Use cash disposal proceeds after relevant tax effects, and include decommissioning or closure payments.

$$\text{Terminal cash flow} = \text{Operating cash} + \text{Recovery} + \text{Disposal} - \text{Closure}$$

Do not assume that every working-capital balance or asset value is fully recoverable.

2 Worked example: a three-year asset

Cash-flow item	Amount and timing
Equipment plus working capital	\$10,000 + \$2,000 at time 0
Net operating cash	\$4,000 at each of 3 year-ends
Working-capital recovery	\$2,000 at end of Year 3
Net disposal / closure	\$1,000 inflow / \$500 outflow in Year 3

$$\text{Year 3 total} = \$4,000 + \$2,000 + \$1,000 - \$500 = \$6,500$$

$$\text{NPV at 10\%} = -12,000 + 4,000/1.10 + 4,000/1.10^2 + 6,500/1.10^3$$

$$\text{NPV} = -\$174.31$$

3 Check what the model already includes

This example assumes the stated net operating and disposal cash amounts already reflect any relevant taxes. Do not deduct the same cash tax or recovery twice.

Book value is not automatically a disposal receipt. If a cash payment or recovery occurs after operations stop, extend the cash-flow timeline to its actual date.

Independent or mutually exclusive?

The same project NPVs can support different selection decisions.

1 Identify the decision before ranking

Independent projects can be undertaken together if resources allow. Mutually exclusive alternatives compete for the same need, so selecting one excludes the other.

For feasible, comparable alternatives, maximizing financial value means choosing the higher NPV. Apply a consistent horizon and appropriate risk-adjusted rates.

2 Worked example: two four-year alternatives

Input or result	Project A	Project B
Initial outlay	\$20,000	\$25,000
Annual year-end inflow	\$8,000	\$10,000
Required return	10%	10%
NPV	+\$5,358.92	+\$6,698.65

Extra investment for B = \$5,000

Extra annual receipt = \$2,000 for 4 years

Incremental NPV = \$6,698.65 - \$5,358.92 = +\$1,339.73

If only one may be selected and both are feasible, B adds more value.

3 Check the alternative decision

If A and B are independent, their cash flows do not interact and sufficient funding and capacity exist, both positive-NPV projects can be accepted. Their combined initial funding is \$45,000.

Do not simply add NPVs when projects share benefits, compete for the same sales or change each other's costs. Model the combined choice explicitly.

Compare different useful lives fairly

Equivalent annual value requires a justified replacement assumption.

1 Make the comparison period meaningful

When alternatives provide a continuing service and can be repeated on comparable terms, convert each NPV into an equivalent annual annuity, or build a common-horizon replacement chain.

Equivalent annual annuity $EAA = NPV \div PV \text{ annuity factor}$

EAA is a constant annual value equivalent, not the actual cash receipt and not an annual ROI percentage.

2 Worked example: repeatable project alternatives

Assume comparable risk, a 10% rate and credible repetition on unchanged economic terms.

Alternative	Life	NPV	Equivalent annual value
A	3 years	\$6,000	\$2,412.69
B	6 years	\$9,000	\$2,066.47

A: $\$6,000 \div 2.486852... = \$2,412.69 \text{ per year}$

B: $\$9,000 \div 4.355261... = \$2,066.47 \text{ per year}$

A has the higher equivalent annual net value under these assumptions.

3 Cross-check the replacement chain

A repeated over 6 years: $\$6,000 + \$6,000/1.10^3 = \$10,507.89$

That common-horizon value exceeds B's \$9,000. The second A project begins at Year 3, so its own start-date NPV must be discounted back to today.

If repetition is unrealistic, model the actual options after each project ends. Do not automatically annualize one-off opportunities and assume they can be repeated forever.

Choose projects within a capital limit

The highest ratio does not always give the best feasible portfolio.

1 Use the profitability index carefully

$$PI = PV \text{ of future net inflows} \div \text{Initial investment}$$

This simple PI form assumes a single time-0 outlay and positive future net cash flows. PI above 1 corresponds to positive NPV for that model.

Ratio ranking can help when investments are divisible. For indivisible projects, compare feasible combinations and maximize total NPV within the constraints.

2 Worked example: a \$100,000 initial budget

Project	Initial outlay	NPV	PI
A	\$60,000	\$30,000	1.50
B	\$50,000	\$22,000	1.44
C	\$50,000	\$22,000	1.44

Assume independent, indivisible projects, additive NPVs and no other constraints.

Choose A alone: cost \$60,000; total NPV \$30,000

Choose B + C: cost \$100,000; total NPV \$44,000

B + C creates \$14,000 more NPV than choosing the highest-PI project A.

3 Model the real constraints

After choosing A, the remaining \$40,000 cannot fund B or C. That is why a greedy ratio ranking fails in this example.

For larger portfolios, enumerate feasible combinations or use an optimization model. Include staff, timing, dependencies and funding limits in later periods when they bind.



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technology, and more.

Find the break-even annual cash flow

Solve for the receipt that makes NPV equal to zero.

① Rearrange the equal-cash-flow model

$$NPV = -I + C \times PV \text{ factor}$$

$$\text{At } NPV = 0: \text{Break-even cash flow } C = I \div PV \text{ factor}$$

Assume equal year-end net cash flows, one initial investment, a constant discount rate and no additional terminal cash flow. Change the formula if these assumptions change.

② Worked example: the \$20,000 project

Life = 4 years. Required return = 10%. PV factor = 3.169865...

$$\text{Break-even } C = \$20,000 \div 3.169865...$$

$$= \$6,309.42 \text{ per year, rounded}$$

The base forecast on page 9 is \$8,000 per year.

$$\text{Annual forecast cushion} = \$8,000 - \$6,309.42 = \$1,690.58$$

Below the break-even receipt, NPV is negative if the other inputs stay fixed.

③ Use the threshold as a question for the forecast

Ask whether annual net cash of about \$6,309 is achievable and how sensitive that estimate is to sales, operating costs and timing. Keep full precision when testing the exact zero-NPV point.

This threshold is not a probability of success. To estimate that probability, a justified model of uncertain cash flows and their dependencies is needed.

Sensitivity and scenarios reveal fragility

Show how uncertain assumptions can change the financial conclusion.

1 Separate a scenario from a probability

Sensitivity analysis changes selected inputs while holding the rest fixed. A scenario is a coherent set of assumptions. Low, base and high labels do not automatically define probabilities.

Use evidence to define ranges and any scenario weights. If probabilities are assigned, the scenarios must be mutually exclusive and collectively cover the model.

2 Worked example: four annual cash receipts

Initial outlay = \$20,000; horizon = 4 years; discount rate = 10%. Each scenario has its stated net inflow at every year-end.

Scenario	Annual net inflow	NPV
Low	\$6,000	-\$980.81
Base	\$8,000	+\$5,358.92
High	\$10,000	+\$11,698.65

For illustrative weights of 25%, 50% and 25%:

$$\text{Expected NPV} = 0.25 \times (-980.81) + 0.50 \times 5,358.92 + 0.25 \times 11,698.65$$

Expected NPV is about +\$5,358.92; a negative scenario remains possible.

3 Test timing and the required return too

Keeping annual inflow at \$8,000 but using a 15% rate gives NPV = \$2,839.83. Delayed receipts can also reduce value even when their total is unchanged.

An average NPV does not describe the largest possible loss, funding pressure or delivery constraints. Report important downside cases beside the base forecast.

Spreadsheet checks: NPV and XNPV

The spreadsheet function must match the timing in your model.

1 A compact worksheet for the opening example

Enter the annual discount rate 10% in E1. Put actual Excel dates in column A and signed cash flows in column B:

Row	Date in column A	Cash flow in column B
2	1 Jan 2025	-10,000
3	1 Jan 2026	4,000
4	1 Jan 2027	4,000
5	1 Jan 2028	4,000

2 Use the correct function and range

Regular year-end periods: $=NPV(E1,B3:B5)+B2$

Excel NPV treats the first listed value as one period ahead. Add the time-0 cash flow separately.

Dated cash flows: $=XNPV(E1,B2:B5,A2:A5)$

XNPV includes the initial dated cash flow in the range and uses actual elapsed days with a 365-day basis.

Both return about $-\$52.59$ here: the chosen intervals are exactly 365 days.

3 Avoid the common timing mistakes

Do not place B2 inside Excel NPV and then add it again. Enter a numerical zero for an empty cash-flow period; a blank cell in a reference is ignored.

For irregular dates, use XNPV with an annual rate and matching value/date ranges. Leap years can make XNPV differ from a simple annual-period NPV. Keep the earliest date first and use real date values.

Integrated case: the faster project may lose

Bring return, recovery, value and constraints into one decision.

1 Compare two mutually exclusive three-year projects

Both are feasible within a \$12,000 initial budget. Use the same 10% annual required return, with cash received only at year-end and no other cash flows.

Input	Project A	Project B
Initial outlay	\$10,000	\$12,000
Year 1 inflow	\$6,000	\$1,000
Year 2 inflow	\$6,000	\$5,000
Year 3 inflow	\$0	\$10,000

2 Calculate the three measures

Measure	Project A	Project B
Simple total-period ROI	20.00%	33.33%
Simple payback	2 years	3 years
NPV at 10%	+\$413.22	+\$554.47

$ROI(B) = (\$16,000 - \$12,000) \div \$12,000 \times 100 = 33.33\%$

$Extra\ NPV\ from\ B = \$554.47 - \$413.22 = \$141.25$

A recovers cash sooner. B has the higher modeled NPV.

3 Make the recommendation conditional and clear

If maximizing financial value is the objective and both alternatives remain feasible, prefer B. Its advantage is small, so test the later \$10,000 receipt and other uncertain assumptions.

If a strict two-year payback policy applies, B fails that constraint and A may be the feasible choice. Record the policy, forecast risk, strategic fit and decision owner instead of hiding them inside a single score.

Formula desk reference and sources

Write down the convention, the dates and the assumptions with every answer.

① Core calculations

$$\text{Simple ROI} = (\text{Net cash gain} \div \text{Initial outlay}) \times 100$$

$$\text{Regular-flow payback} = \text{Initial outlay} \div \text{Cash per period}$$

$$\text{PV} = \text{Cash flow at } t \div (1 + r)^t$$

$$\text{NPV} = \text{Sum of all discounted cash flows, including time 0}$$

$$\text{PV annuity factor} = [1 - (1 + r)^{-n}] \div r$$

Payback needs a timing assumption. The annuity factor is n when $r = 0$.

② Five checks before selecting a project

1. Include only relevant incremental cash flows; document the full horizon.
2. Keep timing, signs, taxes, currency, inflation and discount rates consistent.
3. Compare value and cash recovery; distinguish independent projects from alternatives.
4. Apply funding, capacity and strategic constraints; examine downside cases.
5. Record the assumptions, decision owner and conditions for updating the analysis.

The best calculation is one that makes the decision and its assumptions clear.

③ Primary references and further reading

[1] HBS Online: How to Calculate ROI to Justify a Project.

[2] OpenStax, Principles of Finance 2e, Chapter 16: capital budgeting.

[3] Microsoft Support: NPV function.

[4] Microsoft Support: XNPV function.

[5] ACCA: Advanced investment appraisal.

[6] ACCA: Inflation and investment appraisal.

Titles are clickable in the PDF. Examples are original and illustrative; adapt inputs to project evidence.