DegreeLive

Bachelor of Commerce (B2001) | Level 2 • Part B Major | Monash University

Corporate Finance

Course Code: BFC2140 • Module 2 Notes

Module 2: Capital Budgeting, Free Cash Flow Estimation & Project Risk Analysis

2.1 Capital Budgeting Framework and Investment Criteria

Capital budgeting is the process by which corporate management identifies, evaluates, selects, and monitors long-term capital investments—such as new manufacturing facilities, enterprise software platforms, resource extraction sites, or corporate acquisitions—whose economic cash flows extend over multiple years. Because capital expenditures often entail large, irreversible upfront outlays, disciplined project appraisal lies at the core of shareholder wealth maximisation.

In corporate practice, proposed investments fall into three structural categories. **Independent projects** have cash flows unrelated to one another, so accepting one project does not preclude accepting another provided capital is available. **Mutually exclusive projects** represent alternative ways of achieving the same commercial objective (for example, choosing between two warehouse automation designs or two fleet vehicle types), meaning only one alternative can be selected. **Capital-rationed projects** arise when internal or external funding ceilings limit total initial capital expenditure below the aggregate cost of all positive-NPV proposals.

Net Present Value (NPV)

The **Net Present Value (NPV)** rule is the gold standard of capital budgeting because it directly measures the dollar wealth created for shareholders in today's dollars. NPV equals the present value of all expected future incremental free cash flows discounted at the project's risk-adjusted opportunity cost of capital (r), less the initial investment outlay (CF_0, typically negative):

$$\text{NPV} = CF_0 + \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} = \sum_{t=0}^{n} \frac{CF_t}{(1+r)^t}$$

Where: CF_0 is the net incremental cash flow at $t = 0$ (normally negative initial investment); CF_t is the expected incremental free cash flow in period t; r is the risk-adjusted discount rate (cost of capital); and n is the project's economic life.

The decision rule is unambiguous: accept independent projects with $\text{NPV} > 0$ (which increase firm value by exactly NPV), reject projects with $\text{NPV} < 0$, and among mutually exclusive projects choose the single alternative with the highest positive NPV. Crucially, NPV satisfies three essential economic properties: it uses all cash flows rather than accounting profits, accounts fully for the time value of money and systematic risk, and obeys **value additivity** ($\text{NPV}(A + B) = \text{NPV}(A) + \text{NPV}(B)$).

Payback Period, Discounted Payback, and Accounting Rate of Return (ARR)

Despite the theoretical supremacy of NPV, Australian corporate surveys consistently document that boards and project committees also inspect supplementary metrics such as Payback Period, Discounted Payback Period, and Accounting Rate of Return (ARR):

- **Payback Period:** The number of years required for cumulative undiscounted project cash inflows to recover the initial cash outlay I_0. Management sets an arbitrary cut-off threshold (e.g., 3 years). Payback offers intuitive insight into liquidity and early-year uncertainty, particularly for capital-constrained small enterprises, yet it violates value maximisation by ignoring the time value of money within the payback window and ignoring all cash flows occurring after the cut-off date.
- **Discounted Payback Period:** The number of years required for cumulative *discounted* cash inflows (at rate r) to recover I_0. While discounted payback incorporates the time value of money—guaranteeing that any project recovering its outlay within a finite horizon has a positive cumulative PV over that horizon—it still ignores post-payback cash flows and therefore remains biased against long-lived infrastructure and R&D investments.

DegreeLive

- **Accounting Rate of Return (ARR):** Defined as average annual accounting net profit after tax divided by either initial investment or average book investment ($\frac{\text{Average Annual NPAT}}{\text{Average Book Value}}$). Because ARR relies on accrual earnings rather than cash flows and disregards the timing of returns, it should never replace DCF analysis in capital allocation.

Profitability Index (PI) and Capital Rationing

The **Profitability Index (PI)**—also termed the benefit-cost ratio—measures the present value of future cash inflows generated per dollar of initial investment:

$$\text{PI} = \frac{\sum_{t=1}^{n} \frac{CF_t}{(1+r)^t}}{I_0} = 1 + \frac{\text{NPV}}{I_0}$$

Where: $I_0 = -CF_0 > 0$ is the initial capital outlay at $t = 0$; and r is the discount rate.

For a single unconstrained project, $\text{PI} > 1$ is mathematically identical to $\text{NPV} > 0$. However, PI cannot be used alone to rank mutually exclusive projects of different scale because a smaller project with a higher ratio may generate less total dollar wealth than a larger project. Instead, PI is specifically suited to **single-period capital rationing** (hard or soft capital budgets at $t = 0$): ranking independent positive-NPV projects in descending order of PI identifies the combination of divisible projects that maximises aggregate NPV per dollar of constrained budget. Where projects are indivisible, integer optimisation checks all feasible combinations that fit within the capital cap.

Worked Example 1: Evaluating Mutually Exclusive Projects and Capital Rationing

A Brisbane distribution business evaluates two mutually exclusive automated sorting systems—System Alpha and System Beta—with an opportunity cost of capital of $r = 10.0\%$ p.a. Cash flows (in AUD) are tabulated below:

Period (t)	System Alpha Cash Flow ($)	PV of Alpha at 10% ($)	System Beta Cash Flow ($)	PV of Beta at 10% ($)
0	-400,000	-400,000	-700,000	-700,000
1	220,000	200,000	260,000	236,364
2	220,000	181,818	340,000	280,992
3	140,000	105,184	440,000	330,579
Total / NPV	**+180,000 (undisc.)**	**NPV = +87,002**	**+340,000 (undisc.)**	**NPV = +147,935**

1. **Payback and Discounted Payback:**
   - *System Alpha:* Cumulative undiscounted inflows reach \$220,000 at $t = 1$ and \$440,000 at $t = 2$, giving Payback $= 1 + \frac{400{,}000 - 220{,}000}{220{,}000} = 1.82$ years. Cumulative discounted inflows reach \$200,000 at $t = 1$, \$381,818 at $t = 2$, and \$487,002 at $t = 3$, giving Discounted Payback $= 2 + \frac{400{,}000 - 381{,}818}{105{,}184} = 2.17$ years.
   - *System Beta:* Cumulative undiscounted inflows reach \$260,000 at $t = 1$, \$600,000 at $t = 2$, and \$1,040,000 at $t = 3$, giving Payback $= 2 + \frac{700{,}000 - 600{,}000}{440{,}000} = 2.23$ years. Cumulative discounted inflows reach \$517,356 at $t = 2$ and \$847,935 at $t = 3$, giving Discounted Payback $= 2 + \frac{700{,}000 - 517{,}356}{330{,}579} = 2.55$ years.
2. **Profitability Index (PI):**

$$\text{PI}_{\text{Alpha}} = \frac{\$487,002}{\$400,000} = 1.2175, \qquad \text{PI}_{\text{Beta}} = \frac{\$847,935}{\$700,000} = 1.2113$$

3. **Decision:** Payback, Discounted Payback, and PI all favour System Alpha. However, because Alpha and Beta are *mutually exclusive* and capital is unconstrained, management must select **System Beta**, which increases shareholder wealth by \$147,935 versus \$87,002 for Alpha (an incremental gain of \$60,933).

DegreeLive

2.2 Internal Rate of Return (IRR), MIRR, and Ranking Conflicts

The **Internal Rate of Return (IRR)** is the discount rate that forces a project's Net Present Value exactly to zero:

$$\text{NPV}(\text{IRR}) = \sum_{t=0}^{n} \frac{CF_t}{(1+\text{IRR})^t} = 0$$

Where: IRR is the project's internal compound rate of return; and CF_t is the net incremental cash flow in period t.

For a conventional independent project (an initial cash outflow at $t = 0$ followed solely by non-negative cash inflows), the IRR rule recommends acceptance when $\text{IRR} > r$ (the hurdle rate or cost of capital) and rejection when $\text{IRR} < r$. Yet IRR suffers from four well-documented analytical pathologies that can mislead decision-makers:

1. **Lending versus Borrowing Cash Flow Patterns:** If a project begins with a positive cash inflow followed by future cash outflows (similar to borrowing money or issuing a warranty), NPV *increases* as the discount rate rises. In such cases, the decision rule reverses: management should accept only if $\text{IRR} < r$.
2. **Multiple IRRs (Non-Conventional Cash Flows):** Whenever cash flow signs change more than once—for instance, in Australian mining or offshore energy projects requiring heavy environmental rehabilitation outflows at decommissioning—Descartes' rule of signs implies there may be as many distinct real IRRs as there are sign reversals (or zero real IRRs). When multiple IRRs exist, the IRR criterion breaks down completely and NPV must be used.
3. **Scale Differences:** IRR measures relative percentage return per dollar invested rather than absolute dollar wealth added. A \$100,000 project returning 40% IRR (NPV ≈ \$27,000) is inferior to a mutually exclusive \$1,000,000 project returning 22% IRR (NPV ≈ \$109,000) at a 10% hurdle rate.
4. **Timing Differences and the Crossover Rate:** Even when two mutually exclusive projects require identical initial outlays, one project may pay heavily in early years while the other concentrates cash flows in later years. Because IRR implicitly assumes intermediate cash inflows are reinvested at the IRR itself rather than at the market cost of capital r, NPV profiles of the two projects can cross at a **crossover rate** (Fisher intersection). Below the crossover rate, the longer-dated project yields higher NPV; above it, the front-loaded project yields higher NPV.

Modified Internal Rate of Return (MIRR)

The **Modified Internal Rate of Return (MIRR)** resolves both the multiple-IRR problem and the unrealistic reinvestment rate assumption of standard IRR. MIRR discounts all negative cash flows back to $t = 0$ at the financing/cost of capital rate r, compounds all positive cash inflows forward to the terminal date n at the reinvestment rate r, and calculates the single compound growth rate equating the present value of outflows ($\text{PV}_{\text{outflows}}$) to the terminal future value of inflows ($\text{TV}_{\text{inflows}}$):

$$\text{MIRR} = \left(\frac{\text{TV}_{\text{inflows}}}{\text{PV}_{\text{outflows}}}\right)^{\frac{1}{n}} - 1$$

$$\text{TV}_{\text{inflows}} = \sum_{t=0}^{n} CF_t^{+}(1+r)^{n-t}$$

Where: CF_t^{+} denotes positive cash inflows in period t; $\text{PV}_{\text{outflows}}$ is the absolute present value of negative cash flows discounted at r; r is the cost of capital; and n is the project horizon.

DegreeLive

Worked Example 2: Crossover Rate, NPV Profile, and MIRR

An Adelaide agribusiness compares two mutually exclusive irrigation upgrades requiring the same \$500,000 initial outlay at $t = 0$, with a cost of capital $r = 10.0\%$ p.a. Project Quick delivers front-loaded cash flows of (\$380,000, \$200,000, \$80,000) in Years 1–3, whereas Project Long delivers back-loaded cash flows of (\$100,000, \$250,000, \$400,000) in Years 1–3.

1. **Compute IRR and NPV at $r = 10.0\%$:**
   - *Project Quick:* $\text{NPV}_{10\%} = -500,000 + \frac{380,000}{1.10} + \frac{200,000}{1.10^2} + \frac{80,000}{1.10^3} = \$70,849$; $\text{IRR}_{\text{Quick}} = 19.44\%$.
   - *Project Long:* $\text{NPV}_{10\%} = -500,000 + \frac{100,000}{1.10} + \frac{250,000}{1.10^2} + \frac{400,000}{1.10^3} = \$98,047$; $\text{IRR}_{\text{Long}} = 18.89\%$.

   Notice the ranking conflict: $\text{IRR}_{\text{Quick}}(19.44\%) > \text{IRR}_{\text{Long}}(18.89\%)$, yet NPV_{Long} (\$98,047) exceeds $\text{NPV}_{\text{Quick}}$ (\$70,849) because Project Long receives its largest cash flow later and faces less reinvestment penalty at $r = 10.0\%$.
2. **Find the Crossover Rate (r^*) using incremental cash flows (**$\text{Long} - \text{Quick}$**):**
   - $t = 0$: -\$500,000 - (-\$500,000) = \$0
   - $t = 1$: \$100,000 - \$380,000 = -\$280,000
   - $t = 2$: \$250,000 - \$200,000 = +\$50,000
   - $t = 3$: \$400,000 - \$80,000 = +\$320,000

   Setting incremental NPV to zero:

   $$-280,000 + \frac{50,000}{1 + r^*} + \frac{320,000}{(1 + r^*)^2} = 0$$

   Let $x = \frac{1}{1+r^*}$, giving $(320x^2 + 50x - 280 = 0)$. Applying the quadratic formula:

   $$x = \frac{-50 + \sqrt{50^2 - 4(320)(-280)}}{640} = \frac{-50 + \sqrt{360,900}}{640} = \frac{550.7495}{640} = 0.860546$$

   $$r^* = \frac{1}{0.860546} - 1 = 0.16205 = 16.21\%$$

   For any discount rate $r < 16.21\%$, Project Long has the higher NPV; for $r > 16.21\%$, Project Quick has the higher NPV.
3. **Calculate MIRR for both projects at reinvestment rate $r = 10.0\%$:**

   $$\text{TV}_{\text{Quick}} = \$380,000(1.10)^2 + \$200,000(1.10)^1 + \$80,000 = \$759,800$$

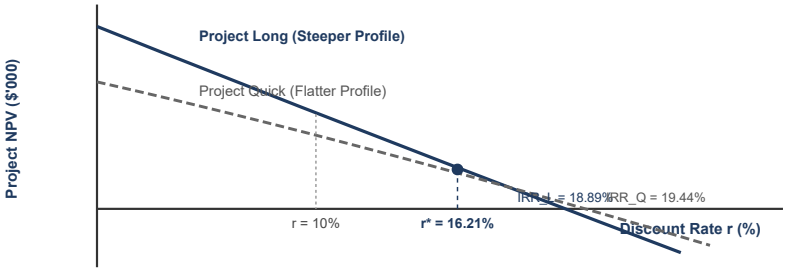
   $$\text{MIRR}_{\text{Quick}} = \left(\frac{\$759,800}{\$500,000}\right)^{1/3} - 1 = 14.97\%$$

   $$\text{TV}_{\text{Long}} = \$100,000(1.10)^2 + \$250,000(1.10)^1 + \$400,000 = \$796,000$$

DegreeLive

$$\text{MIRR}_{\text{Long}} = \left(\frac{\$796,000}{\$500,000}\right)^{1/3} - 1 = 16.77\%$$

Because both projects have the same initial investment ($500,000) and horizon (3 years), MIRR cleanly resolves the timing conflict in favour of Project Long (16.77% > 14.97%), matching the NPV ranking.



2.3 Estimating Incremental Free Cash Flows Under Australian Tax Rules

Accurate capital budgeting relies on estimating **after-tax incremental Free Cash Flows to the Firm (FCFF)**—the additional cash flows the company as a whole will generate if the project is undertaken relative to the counterfactual without the project (the *stand-alone principle*). Correctly isolating incremental cash flows requires strict adherence to five core principles:

- **Exclude Sunk Costs:** Past outlays already incurred or contractually committed regardless of the project decision (such as a $150,000 feasibility study completed last year) are irreversible and must be ignored.
- **Include Opportunity Costs:** Using an existing company-owned asset (e.g., vacant industrial land in Dandenong) is not free; the project must be charged its current after-tax market value (net proceeds foregone if sold today).
- **Include Side Effects (Cannibalisation and Synergies):** If launching a new retail product reduces sales of an existing product line, the lost after-tax contribution margin must be deducted from the new project's cash flows. Conversely, net incremental sales generated for existing divisions are added.
- **Exclude Financing Costs:** Interest expense, debt principal repayments, and dividends are excluded from project Free Cash Flows because the required return to debt and equity providers—along with the interest tax shield—is incorporated into the Weighted Average Cost of Capital (WACC).
- **Inflation Consistency:** Nominal cash flows (incorporating expected price and wage inflation) must be discounted at a nominal WACC; real cash flows must be discounted at a real WACC.

Free Cash Flow Formula and Australian Tax Depreciation (Division 40)

In each operating period t, incremental Free Cash Flow to the Firm equals After-Tax Operating Cash Flow minus Net Capital Expenditure and minus Changes in Net Working Capital (ΔNWC_t):

$$\text{FCFF}_t = \text{EBIT}_t(1 - t_c) + D_t - \text{CapEx}_t - \Delta\text{NWC}_t$$

Equivalently, writing $\text{EBIT}_t = R_t - C_t - D_t$ isolates the **depreciation tax shield** ($t_c D_t$):

$$\text{FCFF}_t = (R_t - C_t)(1 - t_c) + t_c D_t - \text{CapEx}_t - \Delta\text{NWC}_t$$

DegreeLive

Where: R_t is incremental cash revenue; C_t is incremental cash operating expenses; D_t is tax-deductible depreciation; t_c is the Australian corporate tax rate (30% standard rate, or 25% for base rate entities with aggregated turnover under $50 million); CapEx_t is net capital expenditure (outflow positive, net after-tax salvage inflow negative); and $\Delta\text{NWC}_t = \text{NWC}_t - \text{NWC}_{t-1}$ is the net cash tied up in working capital (inventory plus receivables minus payables).

Under Division 40 of the Australian *Income Tax Assessment Act 1997 (Cth)* administered by the Australian Taxation Office (ATO), depreciating assets are written off over their ATO-determined effective life (L) using either the **Prime Cost** (straight-line) method or the **Diminishing Value** method:

$$D_t^{\text{Prime Cost}} = \text{Asset Cost} \times \frac{1}{L}, \qquad D_t^{\text{Diminishing Value}} = \text{Opening Adjustable Value}_t \times \frac{200\%}{L}$$

Where: L is the asset's effective life in years; and Opening Adjustable Value (tax book value) equals initial cost minus accumulated tax depreciation claimed in prior years. Note that ATO tax depreciation ignores estimated salvage value when computing annual deductions; instead, when the asset is sold or scrapped at the end of the project, any difference between actual sale proceeds (SV) and the asset's closing tax Adjustable Value (BV_{tax}) triggers a **balancing adjustment** under s 40-285:

$$\text{After-Tax Salvage Value} = SV - t_c(SV - BV_{\text{tax}})$$

Where: SV is the pre-tax salvage/disposal proceeds; BV_{tax} is the closing tax book value; and t_c is the corporate tax rate. If $SV > BV_{\text{tax}}$, the gain is taxed at t_c; if $SV < BV_{\text{tax}}$, the loss generates a tax saving of $t_c(BV_{\text{tax}} - SV)$.

Worked Example 3: Full 4-Year Incremental FCFF Schedule (Melbourne Manufacturing Plant)

An ASX-listed Victorian manufacturer evaluates a 4-year automation line costing $2,400,000 upfront ($t = 0$). The firm previously spent $90,000 on engineering consultants to scope the site. Management estimates incremental annual revenues of $1,650,000 and incremental cash operating expenses of $650,000 in each of Years 1–4. The plant falls under a 30% Australian corporate tax rate ($t_c = 0.30$) and uses ATO Prime Cost depreciation over a 5-year effective life (D_t = $2,400,000 / 5 = $480,000 p.a.), leaving a non-zero tax adjustable value upon Year 4 disposal for expected market salvage proceeds of SV = $420,000. Net Working Capital of $180,000 is required at $t = 0$ and recovered in full at $t = 4$. The project's nominal WACC is $r = 11.0\%$ p.a.

1. **Treatment of Sunk Cost:** The $90,000 feasibility outlay is sunk and excluded from all cash flows.
2. **Annual Operating Cash Flow (Years 1–4):**

$$\text{EBIT} = \$1,650,000 - \$650,000 - \$480,000 = \$520,000$$

$$\text{OCF} = \text{EBIT}(1 - 0.30) + D_t = \$520,000(0.70) + \$480,000 = \$364,000 + \$480,000 = \$844,000 \text{ p.a.}$$

   Equivalently, using the tax-shield form: ($1,650,000 – $650,000)(0.70) + 0.30($480,000) = $700,000 + $144,000 = $844,000.

3. **Year 4 Balancing Adjustment and After-Tax Salvage Value:**

$$BV_{\text{tax},4} = \$2,400,000 - 4(\$480,000) = \$480,000$$

DegreeLive

> $$\text{After-Tax Salvage} = \$420,000 - 0.30(\$420,000 - \$480,000) = \$420,000 + \$18,000 = \$438,000$$

Because the machine is sold for \$60,000 below its tax adjustable value, the \$60,000 balancing deduction reduces Year 4 tax by \$18,000.

4. **Compile the Complete Incremental FCFF Schedule and Compute NPV:**

Line Item (\$'000)	Year 0	Year 1	Year 2	Year 3	Year 4
Operating Cash Flow (OCF)	0.00	844.00	844.00	844.00	844.00
Capital Expenditure / After-Tax Salvage	-2,400.00	0.00	0.00	0.00	+438.00
Net Working Capital Cash Flow ($-\Delta$NWC)	-180.00	0.00	0.00	0.00	+180.00
Incremental FCFF (\$'000)	**-2,580.00**	**844.00**	**844.00**	**844.00**	**1,462.00**
PV Factor at 11.0%	1.0000	0.9009	0.8116	0.7312	0.6587
Present Value (\$'000)	**-2,580.00**	**760.36**	**685.01**	**617.12**	**963.06**

> $$\text{NPV} = -\$2,580,000 + \$760,360 + \$685,010 + \$617,120 + \$963,060 = +\$445,550$$

Because the project generates an NPV of +\$445,550 after Australian corporate tax, working capital, and salvage adjustments, management should accept the automation line.

ATO Prime Cost versus Diminishing Value Tax Depreciation

Under Division 40 of the *Income Tax Assessment Act 1997 (Cth)*, Australian companies typically choose between Prime Cost and Diminishing Value (200% / L) depreciation for new plant and equipment. Because Diminishing Value writes off a larger proportion of asset cost in earlier years, it accelerates corporate tax deductions and increases the present value of the depreciation tax shield ($t_c D_t$), even though total cumulative deductions (including any Year 4 balancing adjustment upon disposal) remain identical across both methods.

Applying Diminishing Value (200% / 5 = 40% p.a.) to the \$2,400,000 Melbourne plant above (disposed at \$420,000 in Year 4) illustrates this timing advantage at $r = 11.0\%$ and $t_c = 30\%$:

Year (t)	DV Opening Value (\$)	DV Depreciation (40%) (\$)	DV Tax Shield (30%) (\$)	PC Tax Shield (30%) (\$)	DV vs PC Shield Diff. (\$)
1	2,400,000	960,000	288,000	144,000	+144,000
2	1,440,000	576,000	172,800	144,000	+28,800
3	864,000	345,600	103,680	144,000	-40,320
4 (Operating)	518,400	207,360	62,208	144,000	-81,792
4 (Balancing Adj.)	Closing $BV = 311,040$	Taxable gain \$108,960	-32,688	+18,000 (loss)	-50,688
Cumulative Total	—	**\$1,980,000 net write-off**	**\$594,000**	**\$594,000**	**\$0 (PV +\$46,729)**

DegreeLive

While undiscounted cumulative tax savings equal \$594,000 (30% × [\$2,400,000 − \$420,000]) under both methods, switching to ATO Diminishing Value raises project NPV by +\$46,729 (from +\$445,550 to +\$492,279) purely by bringing tax shields forward to Years 1 and 2.

2.4 Special Capital Budgeting Applications: Unequal Lives and Replacement

Comparing mutually exclusive assets with different economic lives requires careful adjustment whenever the business intends to replace the asset at the end of its useful life. Selecting solely on single-cycle NPV creates a horizon bias favouring longer-lived machines, because two or three cycles of a shorter-lived machine could operate over the same total span.

When projects are expected to be repeated indefinitely on identical economic terms, the **Equivalent Annual Annuity (EAA)**—or **Equivalent Annual Cost (EAC)** when comparing cost-only equipment alternatives—converts each project's single-cycle NPV into a constant level annuity over its life n:

$$\text{EAA} = \frac{\text{NPV}}{\text{PVIFA}(r, n)} = \frac{\text{NPV}}{\frac{1-(1+r)^{-n}}{r}}$$

Where: NPV is the single-cycle net present value (or PV of total lifecycle costs for EAC); r is the discount rate; and n is the economic life of one cycle.

For revenue-generating projects that repeat identically, management selects the option with the highest positive EAA. For mandatory operational equipment with identical output quality (evaluated on cost), management selects the option with the lowest EAC. Similarly, in **asset replacement timing** decisions, an existing machine should be replaced immediately if the EAC of a new challenger is strictly lower than the marginal cost of keeping the defender for one more year (including foregone net salvage value, foregone return on salvage, and next year's after-tax operating cost).

Worked Example 4: Comparing Commercial Fleet Options with Unequal Lives (EAC)

A Sydney courier company must choose between two commercial delivery van fleets that will be replaced continuously on an ongoing basis, with an after-tax real discount rate of $r = 8.0\%$ p.a. Fleet A costs \$180,000 upfront, incurs after-tax annual operating and maintenance costs of \$28,000 p.a., and lasts 4 years with zero salvage value. Fleet B costs \$240,000 upfront, incurs after-tax operating costs of \$22,000 p.a., and lasts 6 years with zero salvage value.

1. **Calculate Present Value of Lifecycle Costs (PV Cost) for one cycle:**
   - *Fleet A (4 years):* $\text{PVIFA}(8\%, 4) = \frac{1-(1.08)^{-4}}{0.08} = 3.31213$

     $$\text{PV Cost}_A = \$180,000 + \$28,000(3.31213) = \$180,000 + \$92,740 = \$272,740$$

   - *Fleet B (6 years):* $\text{PVIFA}(8\%, 6) = \frac{1-(1.08)^{-6}}{0.08} = 4.62288$

     $$\text{PV Cost}_B = \$240,000 + \$22,000(4.62288) = \$240,000 + \$101,703 = \$341,703$$

2. **Convert PV Cost into Equivalent Annual Cost (EAC):**

$$\text{EAC}_A = \frac{\$272,740}{3.31213} = \$82,346 \text{ p.a.}, \qquad \text{EAC}_B = \frac{\$341,703}{4.62288} = \$73,916 \text{ p.a.}$$

Even though Fleet B has a higher single-cycle PV cost (\$341,703 vs \$272,740), its 6-year lifespan spreads the capital outlay more efficiently, lowering annualised economic cost by \$8,430 per year. Management should select **Fleet B**.

Degreelive

2.5 Project Risk Analysis, Sensitivity, Break-Even & Real Options

Point-estimate NPV models rely on expected cash flows, yet real-world projects face demand shocks, input cost inflation, construction delays, and regulatory shifts. Corporate analysts therefore supplement base-case DCF models with structured risk-assessment tools.

Analytical Tool	Methodology	Primary Strength & Limitation
Sensitivity Analysis	Varies one input parameter at a time (e.g., $\pm 15\%$ unit price, volume, or WACC) while holding all other inputs fixed.	Identifies key value drivers requiring tighter forecasting; ignores correlations among inputs (e.g., price and volume).
Scenario Analysis	Evaluates consistent macroeconomic/competitive regimes (e.g., Base, Expansion, Recession) where correlated variables shift together.	Captures joint co-movement across sales, margins, and inflation; tests discrete regimes rather than full distributions.
Monte Carlo Simulation	Samples thousands of random paths from specified probability distributions and correlations for key inputs.	Produces a complete NPV probability distribution; sensitive to specification of input distributions and correlations.
Break-Even Analysis	Determines the minimum annual sales volume (Q^*) at which Accounting Profit = 0 or Project NPV = 0.	Financial (NPV) break-even incorporates opportunity cost of capital, unlike accounting break-even.

Accounting versus Financial (NPV) Break-Even Volume

Accounting break-even volume occurs where EBIT equals zero ($\text{Revenue} - \text{Variable Costs} - \text{Fixed Costs} - D = 0$). However, an accounting break-even project destroys shareholder wealth because it earns a 0% return on invested capital rather than the opportunity cost r. By contrast, the **Financial (NPV) Break-Even Volume** solves for the annual unit volume Q_{NPV} where Operating Cash Flow equals the Equivalent Annual Cost (EAC) of the initial capital outlay:

$$Q_{\text{Acct}} = \frac{FC + D}{P - VC}, \qquad Q_{\text{NPV}} = \frac{\text{EAC}_{\text{CapEx}} + FC(1 - t_c) - t_c D}{(P - VC)(1 - t_c)}$$

Where: P is unit selling price; VC is unit variable cost; FC is annual fixed cash operating costs; D is annual depreciation; t_c is the corporate tax rate; and $\text{EAC}_{\text{CapEx}} = \frac{I_0}{\text{PVIFA}(r,n)}$ (assuming zero salvage and no working capital).

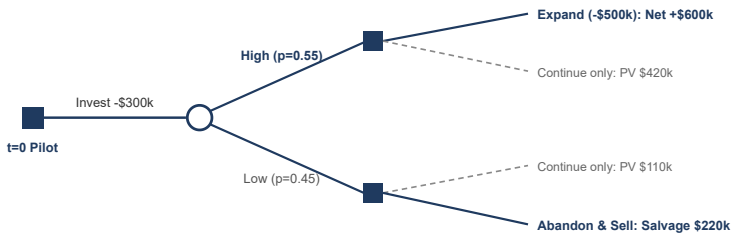
Decision Trees and Real Options

Static NPV assumes a passive "invest now and run unchanged until $t = n$" commitment. In reality, Australian managers possess valuable **real options**—strategic flexibility to adapt future decisions as market uncertainty resolves:

- **Option to Abandon (Put Option):** If early sales disappoint, management can shut down operations and sell plant/equipment for salvage value, truncating downside losses.
- **Option to Expand (Call Option):** A pilot plant or Phase 1 retail rollout allows management to scale up rapidly if initial demand proves strong.
- **Option to Defer / Wait (Timing Option):** Holding undeveloped mining leases or commercial land lets a firm delay irreversible CapEx until commodity prices or interest rates become favourable.
- **Option to Switch Inputs or Outputs:** Flexible manufacturing or dual-fuel power plants allow switching between inputs or product mixes as relative prices fluctuate.

Because managerial flexibility asymmetrically boosts upside outcomes or caps downside losses, true strategic project value equals static NPV plus the value of embedded real options: $\text{NPV}_{\text{strategic}} = \text{NPV}_{\text{static}} + \text{Value of Real Options}$. **Decision-tree analysis** maps sequential decision nodes (squares) and chance/uncertainty nodes (circles), solving backward from terminal payoffs (*backward induction*) to quantify optimal dynamic choices.

Degreelive



Worked Example 5: Financial Break-Even, Sensitivity Table, and Real Option Valuation

Part A — Financial Break-Even Volume: A Perth specialty packaging firm considers a 5-year project requiring an initial machine outlay of \$800,000 ($L = 5$ years, Prime Cost depreciation $D = \$160{,}000$ p.a., zero salvage). Unit price is $P = \$50$, variable cost is $VC = \$30$, annual fixed cash cost is $FC = \$120{,}000$, tax rate is $t_c = 30\%$, and $r = 10.0\%$ p.a. ($\text{PVIFA}(10\%, 5) = 3.79079$).

1. **Accounting Break-Even Volume:**

$$Q_{\text{Acct}} = \frac{\$120{,}000 + \$160{,}000}{\$50 - \$30} = \frac{\$280{,}000}{20} = 14{,}000 \text{ units p.a.}$$

2. **Financial (NPV) Break-Even Volume:** First compute $\text{EAC}_{\text{CapEx}} = \frac{800{,}000}{3.79079} = \$211{,}038$ p.a. Setting annual OCF equal to $\text{EAC}_{\text{CapEx}}$:

$$Q_{\text{NPV}} = \frac{\text{EAC}_{\text{CapEx}} + FC(1 - t_c) - t_c D}{(P - VC)(1 - t_c)}$$

$$Q_{\text{NPV}} = \frac{\$211{,}038 + \$84{,}000 - \$48{,}000}{14} = \frac{\$247{,}038}{14} = 17{,}646 \text{ units p.a.}$$

   At 14,000 units, the project breaks even on accounting profit yet generates a negative NPV; 17,646 units per year are required to earn the 10% cost of capital.

3. **Sensitivity Analysis Around Base-Case Volume ($Q = 22{,}000$ units p.a.):** At $Q = 22{,}000$, annual OCF is 22,000(20)(0.70) – 120,000(0.70) + 48,000 = \$272,000, yielding base-case $\text{NPV} = -800{,}000 + 272{,}000(3.79079) = +\$231{,}095$. Varying each key driver individually by $\pm 15\%$ reveals project risk exposure:

Input Variable	Base Case Value	Downside (-15%) NPV ($)	Upside (+15%) NPV ($)	NPV Swing Range ($)
Unit Selling Price (P)	\$50.00	-\$206,741	+\$668,931	\$875,672
Unit Variable Cost (VC)	\$30.00	+\$493,796 (-15% VC)	-\$31,606 (+15% VC)	\$525,402
Annual Sales Volume (Q)	22,000 units	+\$55,960	+\$406,230	\$350,270
Discount Rate (r)	10.0%	+\$284,487 (8.5% rate)	+\$180,996 (11.5% rate)	\$103,491

Selling price exhibits the largest NPV swing (\$875,672), turning project NPV negative if price falls 15% to \$42.50, signalling that commercial pricing contracts require rigorous market validation prior to commitment.

DegreeLive

Part B — Decision-Tree Real Options Valuation: Consider the two-stage pilot depicted in the decision tree above, with a discount rate of $r = 10.0\%$ p.a. At $t = 0$, the firm invests \$300,000 in a Stage 1 pilot. At $t = 1$, market demand is either High ($p = 0.55$) or Low ($p = 0.45$). Without flexibility (commit at $t = 0$ to continue at $t = 1$ without expanding or abandoning), $t = 1$ payoffs are \$420,000 (High) or \$110,000 (Low), giving static NPV:

$$\text{NPV}_{\text{static}} = -\$300,000 + \frac{0.55(\$420,000) + 0.45(\$110,000)}{1.10} = -\$45,000$$

Now solve by **backward induction** with real options at $t = 1$:

1. **At the High-Demand node ($t = 1$):** Expanding (investing \$500,000 to receive PV \$1,100,000) yields net $t = 1$ value of +\$600,000, which dominates continuing without expansion (\$420,000).
2. **At the Low-Demand node ($t = 1$):** Abandoning and selling pilot assets for \$220,000 dominates continuing operations (\$110,000).
3. **Roll back to $t = 0$:**

$$\text{NPV}_{\text{strategic}} = -\$300,000 + \frac{0.55(\$600,000) + 0.45(\$220,000)}{1.10} = +\$90,000$$

4. **Value of Embedded Real Options:**

$$\text{Real Options Value} = \text{NPV}_{\text{strategic}} - \text{NPV}_{\text{static}} = \$90,000 - (-\$45,000) = \$135,000$$

Although static DCF recommends rejecting the pilot (-\$45,000), the expansion and abandonment options convert the project into a +\$90,000 value creator.

DegreeLive