Integrated course „Energy Economics“
- Financial management -

Chair of Energy Systems | Department of Energy Systems
Technische Universität Berlin

Outline

- Fundamentals of finance
- Time value of money
- Capital structure and cost of capital
- Capital budgeting: NPV method
- NPV vs IRR
- Levelised cost of electricity (LCOE)

Introduction to corporate finance

Understanding how companies invest in new projects

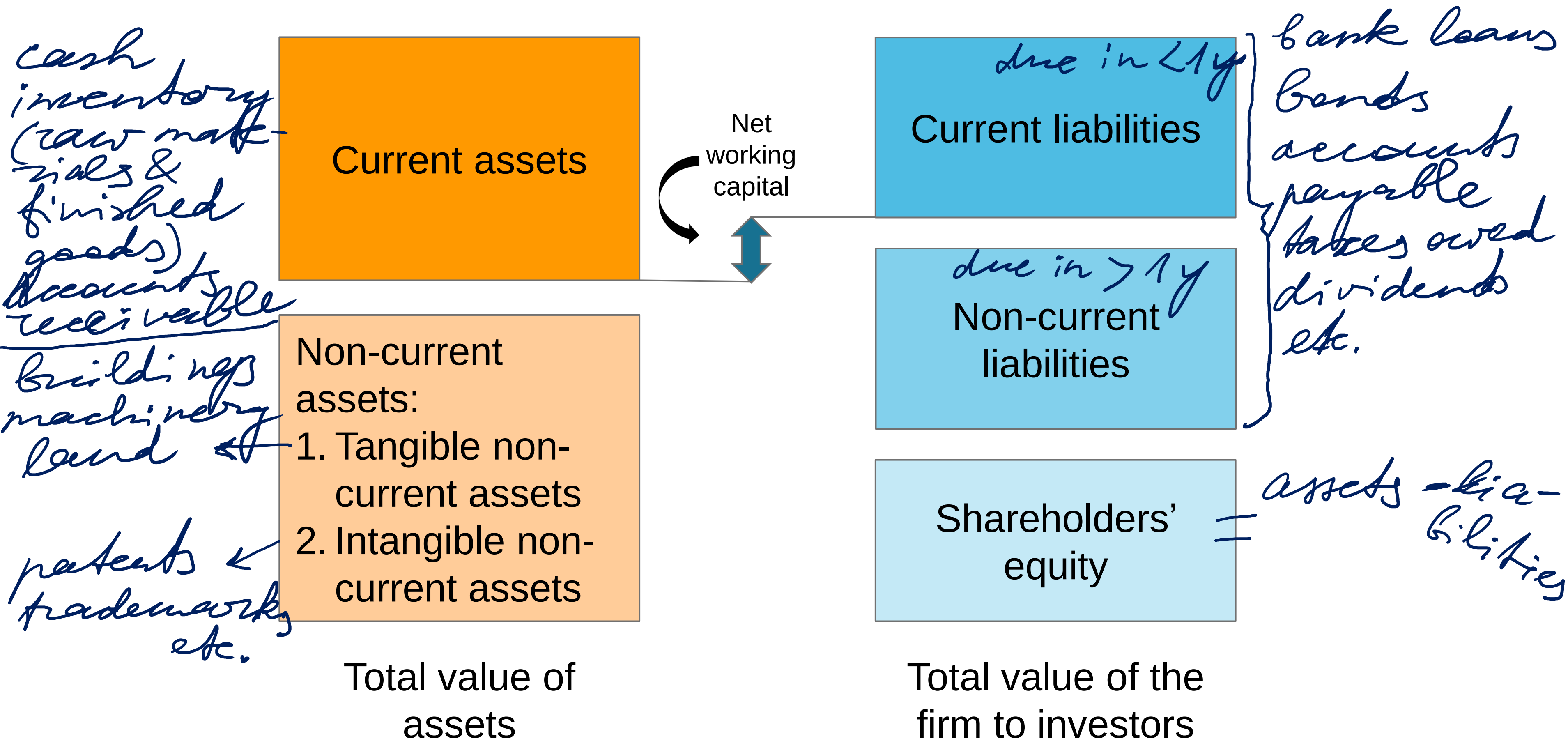
Starting a firm takes investment into **assets**:

inventory (raw materials), machinery, land, and labour.

The amount of cash invested into the assets has to be matched by the amount of cash raised by **financing**.

By producing and selling products, the firm generates cash – the basis of **value creation** for the firm’s owner.

Balance sheet model of the firm



Source: Hillier, Ross, Westerfield, Jaffe, Jordan, 2016

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Balance sheet model of the firm

match amounts and timing of cash inflows & outflows → short-term liquidity

How to manage short-term operating cash flows?

Current assets

Current liabilities

Net working capital

Non-current assets:

1. Tangible non-current assets
2. Intangible non-current assets

Non-current liabilities

Shareholders' equity

Which long-lived assets to invest in?

buy assets that generate more cash than they cost

How to raise cash for capital expenditures?

sell bonds and shares that raise more cash than they cost

Total value of assets

Total value of the firm to investors

Goal: Maximise the value of a company's equity shares.

Source: Hillier, Ross, Westerfield, Jaffe, Jordan, 2016

Methods of project valuation

Static methods

(single-period)

- Cost comparison statement

  \+ operating costs p.a.
  \+ average capital costs p.a.
  <u>+ depreciation p.a.</u>
  annual costs

- Profit comparison

  revenues ./. annual costs

- Return on investment

  EBIT = earnings before interest and tax + interest on debt
  ROI = *EBIT* / avg. capital employed p.a.

- Pay-back period

  Break even = investment / avg. cash flow p.a.

Dynamic methods

(*time value of money*)

- Net present value

  PV = sum of discounted cash flows
  NPV = *PV* - Investition > 0?

- Equivalent annual annuity

  transformation of cash flow series into annuity

- Internal rate of return

  IRR = discount rate at which [*NPV*=0]

Example: Simple payback period method

Energy saving project:

New equipment costs €3.600.

Projected annual energy cost savings: €1.200.

Payback period: $\frac{3600\,€}{1200\,€/a} = 3 \text{ years}$

Change in annual maintenance costs due to the new equipment has to be considered.

Time value of money

Value of an investment depends on the timing of cash flows.

Cash flow is an amount of money paid or received (revenue or expenditure).

Cash flows are characterised by the amount (+/-) and due date.

Time value of money: value of a cash flow at the time it becomes due.

Present value: value of a cash flow at present.

For a cash flow due and payable today:

present value = time value

For a cash flow due and payable at a future time:

present value = time value – interest

Time value of money (continued)

Two proposals for new products to choose between:

Initial cost: €10.000 in each case.

Year	New product A (€)	New product B (€)
1	0	4.000
2	0	4.000
3	0	4.000
4	20.000	4.000
Total	**20.000**	**16.000**

The investment opportunities cannot be compared immediately.

Source: Hillier, Ross, Westerfield, Jaffe, Jordan, 2016

Cashflows: Discounting and compounding

To be able to compare cashflows, they have to be discounted or compounded to the same reference period.

Choice between spending a sum of money or lending it.

Interest rate is the price for obtaining funds for a specified time.

It reflects the opportunity cost in view of other investment options and risk of credit default.

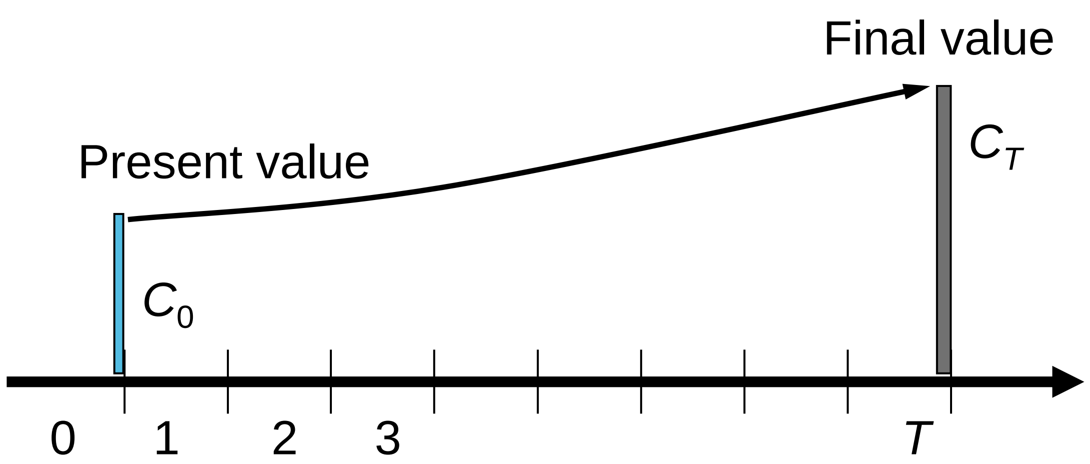
Cash flows: Compounding

- **Compounding:** Present value → future value

$$C_T = C_0 \cdot (1 + i)^T$$

C_0 = the cash flow at date 0 (today) = present value
i = interest rate per period
T = number of periods (time horizon)
C_T = value of the cash flow at time T = future value

Compound interest:
$C_0 \cdot (1+i)$ lended again after 1 period
$(C_0(1+i)) \cdot (1+i)$ lended again after 1 period
etc.

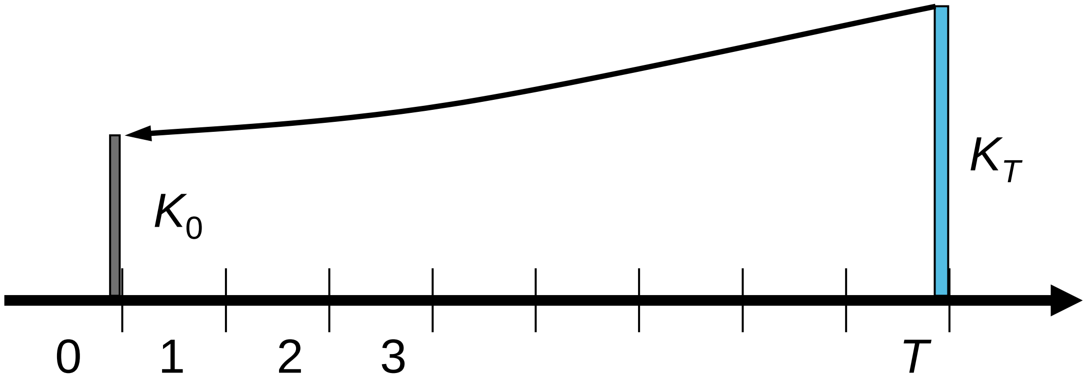


Cash flows: Discounting

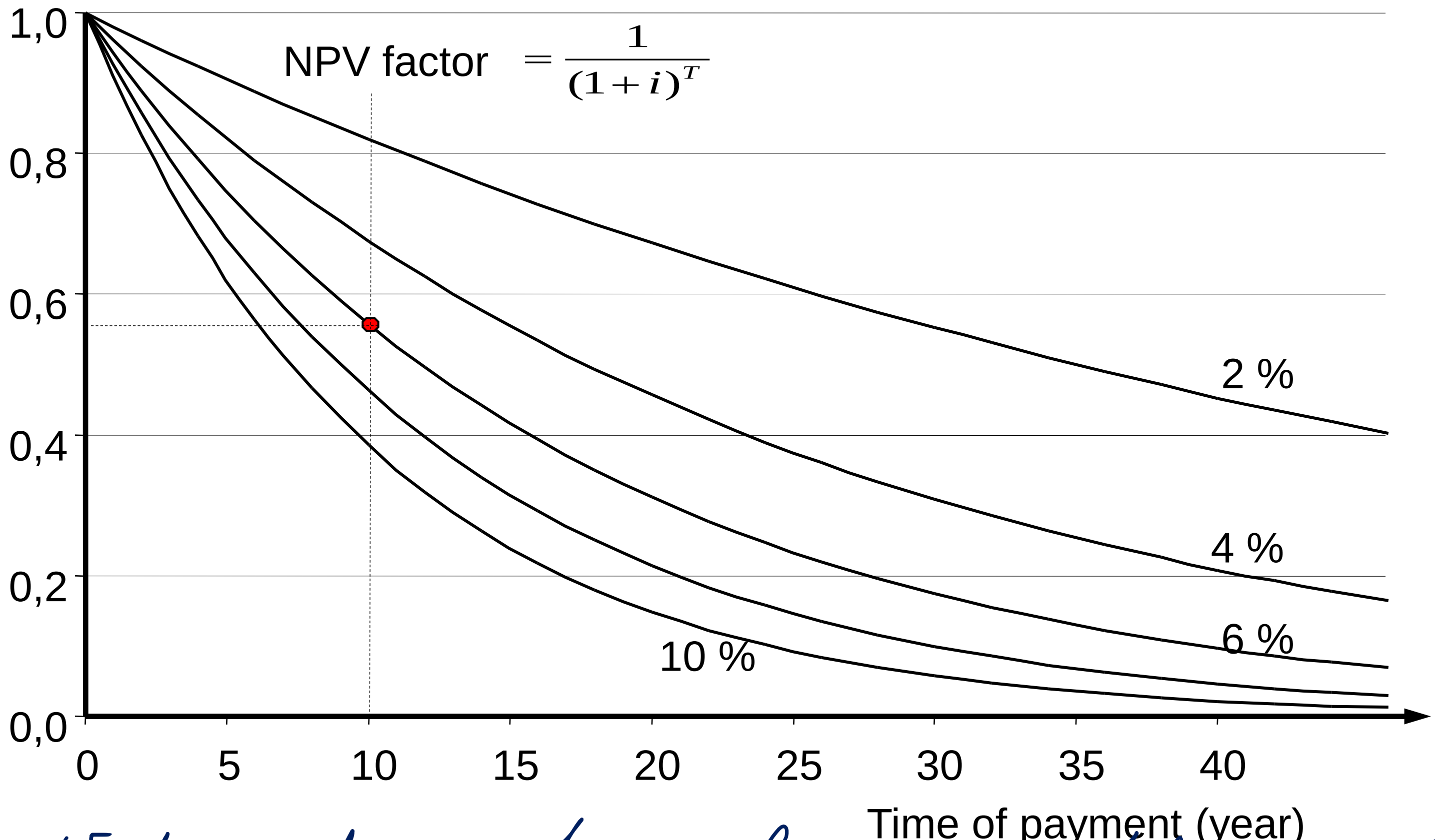
- **Discounting:** Future value → present value

$$C_0 = C_T \cdot \frac{1}{(1 + i)^T}$$

C_0 = value of the cash flow at date 0 (today) = present value
i = interest rate per period
T = number of periods (time horizon)
C_T = the cash flow at time T = future value



Present value of a future cash flow

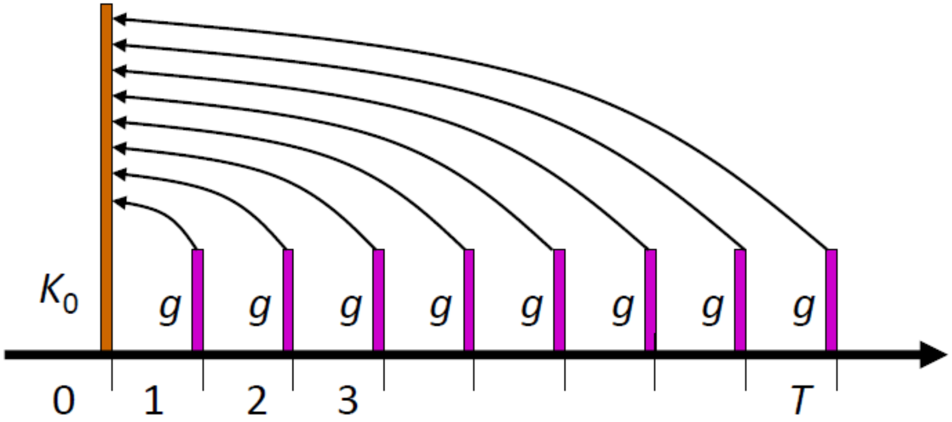


PV depends on time of payment (the sooner, the higher PV) and on the interest rate (the lower the interest rate, the higher PV).

Annuity: NPV with constant cash flows

Annuity is a level stream of regular payments during a fixed number of periods.

K_0 = Present value
g = Periodical payment
i = Interest rate
q = $(1+i)$ Interest factor
T = Number of periods



Value at the end of period 0

$$K_0 = g \cdot \left(1 + \frac{1}{q} + \frac{1}{q^2} + \ldots + \frac{1}{q^T}\right) = g \cdot \frac{q^T - 1}{q - 1} \cdot \frac{1}{q^T} = g \cdot \frac{1 - q^{-T}}{q - 1}$$

$$K_0 = g \cdot \frac{q^T - 1}{q - 1} \cdot \frac{1}{q^T} = g \cdot \frac{1 - q^{-T}}{q - 1}$$

$$K_0 = g \cdot Annuity\ factor_{i,T} \quad with \quad Annuity\ factor_{i,T} = \frac{1}{i} - \frac{1}{i(1+i)^T}$$

Annuity factor

Years	Interest rate [%] 3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
1	0.971	0.966	0.962	0.957	0.952	0.943	0.935	0.926	0.917	0.909
2	1.913	1.900	1.886	1.873	1.859	1.833	1.808	1.783	1.759	1.736
3	2.829	2.802	2.775	2.749	2.723	2.673	2.624	2.577	2.531	2.487
4	3.717	3.673	3.630	3.588	3.546	3.465	3.387	3.312	3.240	3.170
5	4.580	4.515	4.452	4.390	4.329	4.212	4.100	3.993	3.890	3.791
6	5.417	5.329	5.242	5.158	5.076	4.917	4.767	4.623	4.486	4.355
7	6.230	6.115	6.002	5.893	5.786	5.582	5.389	5.206	5.033	4.868
8	7.020	6.874	6.733	6.596	6.463	6.210	5.971	5.747	5.535	5.335
9	7.786	7.608	7.435	7.269	7.108	6.802	6.515	6.247	5.995	5.759
10	8.530	8.317	8.111	7.913	7.722	7.360	7.024	6.710	6.418	6.145
11	9.253	9.002	8.760	8.529	8.306	7.887	7.499	7.139	6.805	6.495
12	9.954	9.663	9.385	9.119	8.863	8.384	7.943	7.536	7.161	6.814
13	10.635	10.303	9.986	9.683	9.394	8.853	8.358	7.904	7.487	7.103
14	11.296	10.921	10.563	10.223	9.899	9.295	8.745	8.244	7.786	7.367
15	11.938	11.517	11.118	10.740	10.380	9.712	9.108	8.559	8.061	7.606
20	14.877	14.212	13.590	13.008	12.462	11.470	10.594	9.818	9.129	8.514
25	17.413	16.482	15.622	14.828	14.094	12.783	11.654	10.675	9.823	9.077
30	19.600	18.392	17.292	16.289	15.372	13.765	12.409	11.258	10.274	9.427
35	21.487	20.001	18.665	17.461	16.374	14.498	12.948	11.655	10.567	9.644
40	23.115	21.355	19.793	18.402	17.159	15.046	13.332	11.925	10.757	9.779
45	24.519	22.495	20.720	19.156	17.774	15.456	13.606	12.108	10.881	9.863
50	25.730	23.456	21.482	19.762	18.256	15.762	13.801	12.233	10.962	9.915

A fixed periodical payment multiplied with applicable ANF returns the present value of the annuity.

Capital recovery factor

$CRF = \frac{1}{AF}$

Years	Interest rate [%] 3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
1	1.030	1.035	1.040	1.045	1.050	1.060	1.070	1.080	1.090	1.100
2	0.523	0.526	0.530	0.534	0.538	0.545	0.553	0.561	0.568	0.576
3	0.354	0.357	0.360	0.364	0.367	0.374	0.381	0.388	0.395	0.402
4	0.269	0.272	0.275	0.279	0.282	0.289	0.295	0.302	0.309	0.315
5	0.218	0.221	0.225	0.228	0.231	0.237	0.244	0.250	0.257	0.264
6	0.185	0.188	0.191	0.194	0.197	0.203	0.210	0.216	0.223	0.230
7	0.161	0.164	0.167	0.170	0.173	0.179	0.186	0.192	0.199	0.205
8	0.142	0.145	0.149	0.152	0.155	0.161	0.167	0.174	0.181	0.187
9	0.128	0.131	0.134	0.138	0.141	0.147	0.153	0.160	0.167	0.174
10	0.117	0.120	0.123	0.126	0.130	0.136	0.142	0.149	0.156	0.163
11	0.108	0.111	0.114	0.117	0.120	0.127	0.133	0.140	0.147	0.154
12	0.100	0.103	0.107	0.110	0.113	0.119	0.126	0.133	0.140	0.147
13	0.094	0.097	0.100	0.103	0.106	0.113	0.120	0.127	0.134	0.141
14	0.089	0.092	0.095	0.098	0.101	0.108	0.114	0.121	0.128	0.136
15	0.084	0.087	0.090	0.093	0.096	0.103	0.110	0.117	0.124	0.131
20	0.067	0.070	0.074	0.077	0.080	0.087	0.094	0.102	0.110	0.117
25	0.057	0.061	0.064	0.067	0.071	0.078	0.086	0.094	0.102	0.110
30	0.051	0.054	0.058	0.061	0.065	0.073	0.081	0.089	0.097	0.106
35	0.047	0.050	0.054	0.057	0.061	0.069	0.077	0.086	0.095	0.104
40	0.043	0.047	0.051	0.054	0.058	0.066	0.075	0.084	0.093	0.102
45	0.041	0.044	0.048	0.052	0.056	0.065	0.073	0.083	0.092	0.101
50	0.039	0.043	0.047	0.051	0.055	0.063	0.072	0.082	0.091	0.101

A loan amount multiplied with applicable CRF returns a constant annual amount needed to repay the loan.

Outlook: $NPV = -I_0 + DCF$ → see below slides

$NPV_A = -10\,000€ + 17\,094€ = 7\,094€$

$NPV_B = -10\,000€ + 14\,520€ = 4\,520€$

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Solution to previous example

Two proposals for new products to choose between:

Initial cost: €10.000 in each case. Find PV of revenues for A and B:

Year	New product A (€)	New product B (€)
1	0	4.000
2	0	4.000
3	0	4.000
4	20.000	4.000
Total	**20.000**	**16.000**

B: annuity

$PV_{annuity} = g \cdot AF_{i,T}$

$AF_{4\%,4y} = 3{,}630$ (see table)

$PV_B = 4000€ \cdot 3{,}630 = 14.520€$

The interest rate is 4%.

$PV(CF_T) = \frac{CF_T}{(1+i)^T}$

$PV_B = \frac{20\,000€}{(1+0{,}04)^4} = \frac{20\,000}{1{,}17} = 17.094€$ → $PV_A > PV_B$

Source: Hillier, Ross, Westerfield, Jaffe, Jordan, 2016

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Discount rate

The discount rate represents cost of capital and project risk.

Risk-free interest rate + risk premium

opportunity to buy government bonds

How to raise cash for capital expenditures?

- Equity (own capital) – raised from shareholders
  - rewarded by dividends + the difference in the market price of shares (if positive)
  - right to share in assets remaining after liabilities in case of liquidation
  - participate in managing the firm
- Debt (borrowed capital) – borrowed from creditors /debtholders
  - rewarded through interest
  - preferred over shareholders (incl. in case of bankruptcy)

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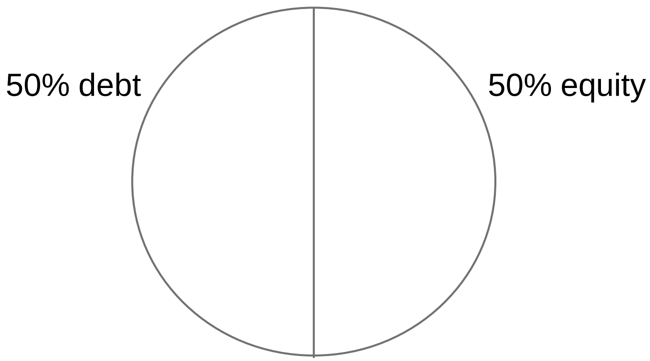
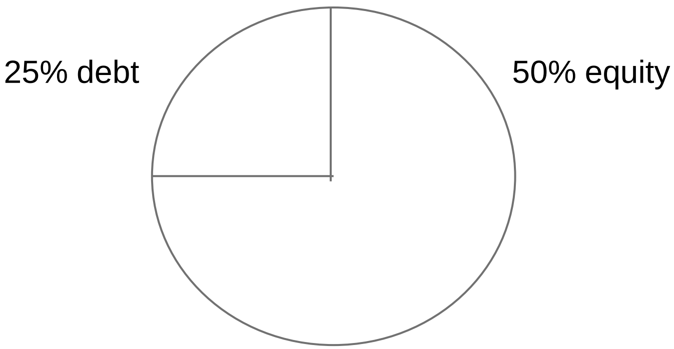
Capital structure: Weighted average cost of capital (WACC)



Capital structure 1



Capital structure 2

$$WACC = \frac{E}{D+E}(r_e) + \frac{D}{D+E}(r_d)(1-t)$$

→ interest tax shield

Where:

E = market value of equity

D = market value of debt

r_e = cost of equity

r_d = cost of debt

t = corporate tax rate

The amount of interest paid on debt is deducted from the taxable income. This reduces the income tax paid by the company.