Luento 4.

Puhtaan siirtymän hankkeiden rahoitus

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Green projects by the present value formula

$$PV(X,r) = \frac{X}{1+r}$$

Profits and costs
Regulatory mandated investments, subsidies

Cost of capital
Subsidies, tax breaks, green finance instruments, green investment clienteles

Agenda going forward

Recap on the cost of capital

Green shift investment project analysis examples

Optimizing capital structure

Green financing instruments

OECD, Suomen maaraportti, 23.5.2025:

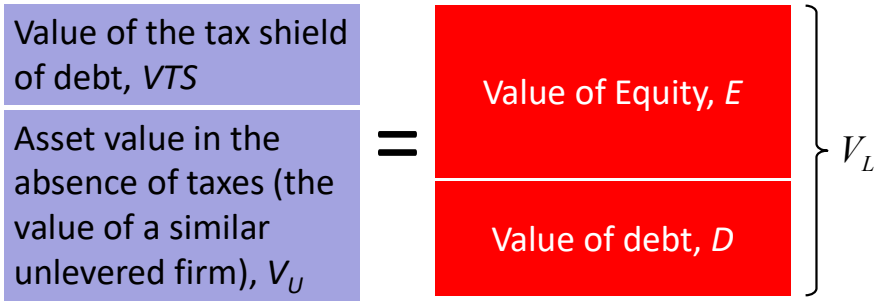
> "*Pääomamarkkinoiden kehittäminen, koulutustason nostaminen, ulkomaisten investointien ja osaavan työvoiman houkutteleminen vihreille aloille auttaisivat Suomea saavuttamaan* [vihreän siirtymän] *mahdollisuudet.*"

Firm value with tax shields

Debt makes (1) equity riskier, but (2) reduces taxes

– Can increase total value (V), at least up to a point

$$V_L^* = V_U + VTS = D + E$$



* Subscript *L*: Levered, i.e., how the firm really is,
U: Unlevered, if it were 100% equity financed

WACC and capital structure weights are obtained recursively

Catskills example again, we computed E = $10.5M. WACC was given. But how did I know WACC before knowing E, and weights E/V and D/V? I didn't. To recap,

Capital structure weights are

$$\frac{D}{D+E} = \frac{5}{15.5} = 0.323, \quad \frac{E}{D+E} = \frac{10.5}{15.5} = 0.677$$

And so WACC is $0.323 \times 4\% + 0.677 \times 15\% = 11.45\%$

But to know this, you solve for E/V and WACC *simultaneously*, or have numerically converge in Excel (start by just guessing a WACC, say 10%)

Getting philosophical on the UCF/WACC

We've done the math and seen how it works, but, once more:

Q: Why do we do it this way, using imaginary UCF cash flows and some wacky WACC?

A: Done this way, the discounting by WACC 'handles' the opportunity cost of capital, including tax shields

Sokrates: Why don't we subtract interest expense, is it not a cash outflow?

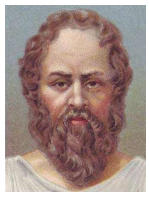
Plato: Well, say we didn't have any debt, and thus no interest expense. Is the capital then free?

S: Okay I see, it is not. If it's 100% equity, then it's just the dividend payment that is the cost of capital?

P: Well, what if the firm didn't pay any dividends?

S: Then the cost of equity would be zero?

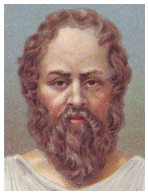
P: Where would you get such equity capital – that doesn't expect anything in return?



S: But if they start paying dividends later?

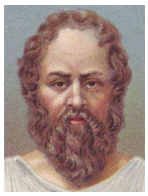
P: Oh, so you're saying the equity would be free for a while –and would only start to cost later on?

S: I see. Then they wouldn't invest until later. I remember our earlier discussion on opportunity costs – investors have their capital in the firm, which means it's not available for some other venture, from which they could maybe have dividends right now. But equity is still not a cost to the firm?



P: Not in an accounting sense. But as you mentioned, it is an opportunity cost for the owners of equity.

S: ...and the equity owners own the firm, so the firm's money equals the owner's money! So, we should actually deduct the cost of, not only interest expense, but the cost of equity too – how do we do that?

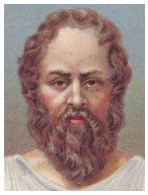


P: We could deduct interest expense, but we can't do it for the opportunity cost of equity – there is no out-of-pocket cash flow to subtract.

S: ...and that's why they came up with the Unlevered Cash Flow method! What a clever idea! You first pretend the cost of capital didn't matter when you calculate cash flows, and then handle the issue with the discount rate!

P: Bro, you're totally digging the philosophy of modern finance!

S: And I have this great aqueduct project that I want to build!



P: Yes, let's go over the numbers! Maybe we can bring in Thales as well, he's loaded from all those olive press deals...

Green shift investment projects

- Cash flow modeling
- Cost of capital considerations

Features of green shift/circular economy investment projects' cash flow projections

Government subsidies, subject to policy changes

Longer project lifecycles and payback

End-of-life costs for decommissioning or recycling

Revenue volatility from fluctuating prices

Regulatory risks and compliance costs

Investment project example: Photovoltaics (PV) energy production facility

Initial investment: 400 (units in thousands)

First year production 350 kWh, solar panel degradation 0.5% per year; Operating cost 5 per year

Project life is 20 years; Decommissioning end cost is 40

Fixed price for selling electricity: 15 cents/kWh

Cost of capital is 6%

Project value

T	kWh	Revenue	CF	PV
0	0.00	0.00	-400.00	-400.00
1	350.00	52.50	47.50	44.81
2	348.25	52.24	47.24	42.04
3	346.51	51.98	46.98	39.44
4	344.78	51.72	46.72	37.00
5	343.05	51.46	46.46	34.72
6	341.34	51.20	46.20	32.57
7	339.63	50.94	45.94	30.56
8	337.93	50.69	45.69	28.67
9	336.24	50.44	45.44	26.89
10	334.56	50.18	45.18	25.23
11	332.89	49.93	44.93	23.67
12	331.22	49.68	44.68	22.21
13	329.57	49.44	44.44	20.83
14	327.92	49.19	44.19	19.54
15	326.28	48.94	43.94	18.34
16	324.65	48.70	43.70	17.20
17	323.03	48.45	43.45	16.14
18	321.41	48.21	43.21	15.14
19	319.80	47.97	42.97	14.20
20	318.20	47.73	2.73	0.85
			NPV:	**110.05**

Internal Rate of Return (IRR)

9.4%

Payback time

Cumulative CF after year 12 is 388, after year 13 it's 409

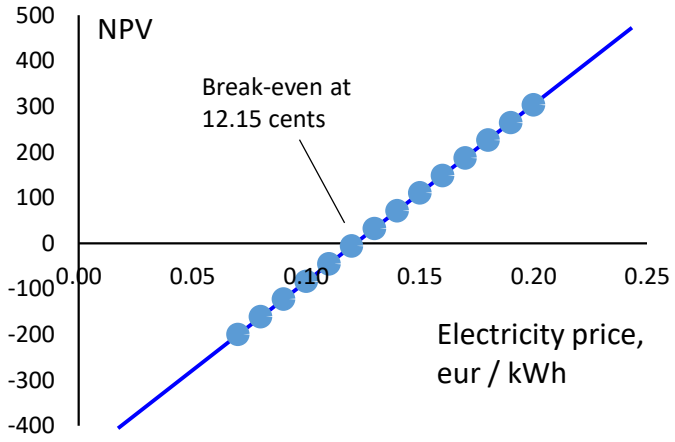
409 − 388 = 21

400 − 388 = 12

12 / 21 = 0.57

→ 12.6 years (12 years 7 months)

Sensitivity analysis



Plastic waste upcycling plant to convert mixed plastic waste into synthetic materials and fuels

Eligible for carbon credits and green subsidies — but only after becoming operational and meeting environmental standards; Project lifetime is 20 years

Construction & R&D: Years 0-3

Pilot & ramp-up: Years 4-5

Full operations: Years 6-20

Carbon credits / subsidies contribute starting Year 6

The discount rate is 7%

Plastic waste upcycling plant NPV and scenario analysis

T	Description	CF (mil.)	PV
0	Land acquisition, R&D	-30	-30.00
1	Construction	-50	-46.73
2		-40	-34.94
3	System integration, permits	-25	-20.41
4	Pilot production begins	-15	-11.44
5	Ramp-up, partial sales	-5	-3.56
6	Full operation starts	10	6.66
7	Stable production, subsidies kick in	20	12.45
8		25	14.55
9	Revenue growth, cost optimization	35	19.04
10	Includes carbon credit sales	40	20.33
11	Peak production, stable inputs	45	21.38
12	Technology licensing revenue begins	50	22.20
13	Stable operations	50	20.75
14	Slightly increasing O&M costs	45	17.45
15	Continued revenue from by-products	40	14.50
16	Carbon credit policy reduced	30	10.16
17	Maintenance capex rises	25	7.91
18	Input waste stream cost increases	20	5.92
19	End of life cycle planning	10	2.77
20	Decommissioning cost	-10	-2.58
		NPV:	**46.41**

What if…

- Full operationality is delayed (assume: year 5 cash flow continues and project life is extended, i.e., entire cash flow pattern shifts forward)

Delay, years	NPV
0	46.4
1	30.4
2	15.5
3	1.5
4	-16.0
5	-29.0

- Ready one year early (assume: skip year 5, project ends one year early): NPV = 63.5

Factors that can reduce cost of capital for green investment projects

Policy-driven risk reduction

Market perception and ESG integration

Technology and policy risks (can go both ways)

Access to green capital markets and instruments

Reduced cost of capital for green investment

Example: Green hydrogen plant vs. traditional natural gas plant

Green Hydrogen: Electrolysis powered by renewable electricity; Sells hydrogen for use in industry, transportation, or energy storage; Contributes to decarbonization (part of EU Green Deal, IRA in the U.S.)

Natural Gas: Conventional gas turbines; Produces electricity for the grid, relies on fossil fuels; No circular economy or decarbonization component

Assume that (in traditional sense), cash flow risks are the same, and general financing structure is the same. What factors could still drive differences in cost of capital between these projects?

Reduced cost of capital for green investment

Policy-driven risk reduction

Green hydrogen project may

- Be eligible for government guarantees, subsidies, or tax credits
- Receive cheaper loans from development banks (e.g., EIB, World Bank)
- Be eligible to green or sustainability-linked bonds and loans with potentially lower interest rates

The above reduces cost of debt. It may also reduce cost of equity through lower bankruptcy risk, lower cash flow volatility, presence of equity anchor investors

Reduced cost of capital for green investment

Market perception and ESG integration

Institutional investors favor higher ESG companies and projects

Green hydrogen project may face lower investor scrutiny and higher capital inflows

Natural gas project may be excluded by some ESG investors

This affects both equity and debt capital costs

Reduced cost of capital for green investment

Technology and policy risk

Green hydrogen may face higher perceived risk due to

- Technological uncertainty (e.g., electrolysis scale-up risk)
- Policy change (e.g., carbon pricing, subsidy)

These would especially increase equity capital cost

Can be offset, or reversed by, e.g., long-term offtake agreements, and government regulatory guarantee

Reduced cost of capital for green investment

Access to green debt capital markets and instruments

Green hydrogen projects qualify for green bonds/loans, or sustainability link bonds (SLB) which can come with below-market interest rates

Traditional gas projects do not qualify and may even face divestment pressure

Reduced cost of capital for green investment

Cost of equity specifically, what factors could lower it in the green hydrogen example

May get a fixed price per kg of hydrogen, or lower bound guarantee, which reduces price volatility risk, reduces revenue risk and thus overall cash flow risk

Governments (or related institutions) may guarantee returns or act as anchor investors

Carbon pricing schemes or tax credits (e.g., U.S. IRA hydrogen tax credits) provide minimum income stream

Governments may help on the demand side, mandating the use of green materials for fuels

Optimizing capital structure

- Components of WACC
- Net benefit of debt

WACC and components in industries

	Total market (ex. financials)	Utility, water	Chemicals, basic	Telecom, wireless
Stock beta	1.1	0.4	1.5	1.3
Stock volatility	43%	23%	54%	44%
r_E	9.4%	5.2%	11.9%	10.2%
D / V	40%	30%	40%	54%
$(1- T_C)\, r_D$	3.4%	2.7%	3.4%	3.4%
WACC	**7.0%**	**4.5%**	**8.5%**	**6.6%**

Source: Aswath Damodaran, NYU

Minimizing WACC components, ceteris paribus

$$WACC = r_D \times (1 - T_C) \times \frac{D}{V} + r_E \times \frac{E}{V}$$

To minimize r_D and r_E

- Transparent and clear accounting, efficient investor communication, credible third-party certification

You can influence the systematic risk of the firm's investments (assets) to some extent

- Cost structure, hedging policy

Optimize capital structure, D/E

- Equity risk and return vs. tax advantage of debt

Effect of (more than marginal) increase of *D*

Value of tax shields (VTS) increases as long as taxable profits are positive

But then...

- New debt is riskier than old (it's more *junior*), so borrowing cost increases, so r_D up
- Equity becomes riskier due to increased leverage, investors' required risk premium increases, so r_E up

Is the total effect > 0 or < 0? Depends on level of D