Capital Budgeting

Lecture Outline

- Review
- Capital budgeting procedure
- Case of Boeing
- Evaluate NPV estimates

Review

- Capital Budgeting（资本预算）
  - Process used to analyze alternate investments and decide which ones to accept
- Accepting positive NPV projects benefits shareholders.
- Estimating NPV:
  1. Estimate future cash flows: how much? and when?
  2. Estimate discount rate

Review--Calculating Free Cash Flow

- Free Cash Flow（自由现金流量）

$$\text{Free Cash Flow} = \overbrace{(\text{Revenues} - \text{Costs} - \text{Depreciation}) \times (1 - \tau_c)}^{\text{Unlevered Net Income}} + \text{Depreciation} - \text{CapEx} - \Delta NWC$$

$$\text{Free Cash Flow} = (\text{Revenues} - \text{Costs}) \times (1 - \tau_c) - \text{CapEx} - \Delta NWC + \tau_c \times \text{Depreciation}$$

  - The term $\tau_c \times$ *Depreciation* is called the depreciation tax shield（税盾）.

Review--Calculating Free Cash Flow

- Capital Expenditures and Depreciation（资本花费和折旧）
  - Capital Expenditures are the actual cash outflows when an asset is purchased. These cash outflows are included in calculating free cash flow.
  - Depreciation is a non-cash expense. Depreciation affects tax bills.

Review--Calculating Free Cash Flow

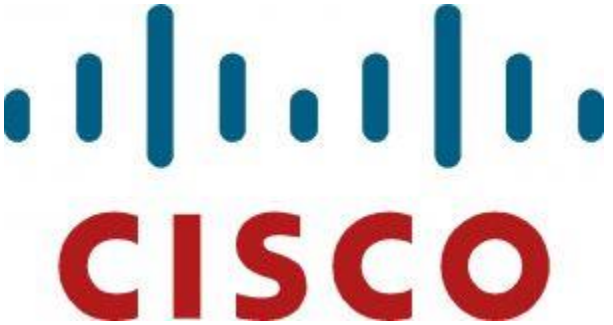
- Interest Expense(利息费用）
  In capital budgeting decisions, *interest expense is typically not included*. The rationale is that the project should be judged on its own, not on how it will be financed.

Review--Calculating Free Cash Flow

- Net Working Capital (NWC)
  （净营运资本）
  - The increase in net working capital is defined as:

$$\Delta NWC_t = NWC_t - NWC_{t-1}$$

Net Working Capital
= Current Assets – Current Liabilities
= Cash + Inventory + Receivables – Payables



我们先来探讨家庭网络产品的收入和成本估计。家庭网络产品的目标市场为高档住宅的“智能”家庭和家庭办公室。基于广泛的市场调查，预测家庭网络的年销售量为100 000 套。考虑到科技变革的速度，路由器分部预计该产品只能生产 4 年。该产品在高保真音响和电子商店的零售价格为 375 美元，预计批发价为每套 260 美元。

开发新硬件相对较便宜，因为基于现有技术，可以将其简单地重新包装成新设计的家庭友好型的路由器。产品外观设计团队会把路由器和它的包装做得具有讨人喜欢的美感。路由器分部预计整个工程和设计的总成本将达到 500 万美元。一旦设计完成，实际的产品制造将以每套 110 美元的成本外包给专业制造商生产。

除了硬件要求外，还要为该产品研发新的应用软件，以实现基于互联网的家庭虚拟控制功能。这一软件开发项目需要网络设备制造商们相互协作，并预计专门需要由 50 名软件工程师组成的团队，耗时一整年才能完成。每位软件工程师的费用（包括薪酬福利和相关费用）为每年 200 000 美元。为检验新的用户因特网接入设备与家庭网络系统的兼容性，还要修建一个新的测试实验室。新实验室将占用现有设施，而且要购买价值750 万美元的新设备。

经过 1 年的研发，软件和硬件的设计将完成，实验室将投入使用。到那时，家庭网络产品将要准备装运。路由器分部预计该产品每年的市场营销和服务支持花费为 280 万美元。

Revenue and Cost Estimates

- Example
  - Revenue Estimates
    - Sales = 100,000 units/year
    - Per Unit Price = $260

Revenue and Cost Estimates

- Cost Estimates
  - Up-Front R&D = $15,000,000
  - Up-Front New Equipment = $7,500,000
    - Expected life of the new equipment is 5 years
    - Housed in existing lab
  - Annual Overhead = $2,800,000
  - Per Unit Cost = $110

$$\begin{aligned}\text{Unlevered Net Income} &= \text{EBIT} \times (1 - \tau_c) \\ &= (\text{Revenues} - \text{Costs} - \text{Depreciation}) \times (1 - \tau_c)\end{aligned}$$

Incremental Earnings Forecast

TABLE 7.1 SPREADSHEET

HomeNet's Incremental Earnings Forecast

	Year	0	1	2	3	4	5
Incremental Earnings Forecast ($000s)							
1	Sales	–	26,000	26,000	26,000	26,000	–
2	Cost of Goods Sold	–	(11,000)	(11,000)	(11,000)	(11,000)	–
3	**Gross Profit**	–	15,000	15,000	15,000	15,000	–
4	Selling, General, and Administrative	–	(2,800)	(2,800)	(2,800)	(2,800)	–
5	Research and Development	(15,000)	–	–	–	–	–
6	Depreciation	–	(1,500)	(1,500)	(1,500)	(1,500)	(1,500)
7	**EBIT**	(15,000)	10,700	10,700	10,700	10,700	(1,500)
8	Income Tax at 40%	6,000	(4,280)	(4,280)	(4,280)	(4,280)	600
9	**Unlevered Net Income**	**(9,000)**	**6,420**	**6,420**	**6,420**	**6,420**	**(900)**

General Rules for Calculating Cash Flows

- Rule 1: Use cash flows, not accounting earnings.
- Rule 2: Use incremental cash flows.

Rule 1: Use cash flows, not accounting earnings.

- Cash flows show when money actually flows in/out at each point in time.
- Accounting: Records transactions - shows when money is earned not when it is paid.
- Accounting earnings are not directly useful for valuation.

Rule 2: Use incremental cash flows.

- Use only cash flows attributable to the project.
  - Do not use **sunk costs**（沉没成本）
- Use all cash flows attributable to the project.
  - Include **opportunity costs(**机会成本）
  - Remember **externalities**（外部性） - good and bad.

Sunk costs

- **Sunk costs** are costs that have been or will be paid regardless of the decision whether or not the investment is undertaken.
  - Sunk costs should not be included in the incremental earnings analysis.

Opportunity Cost

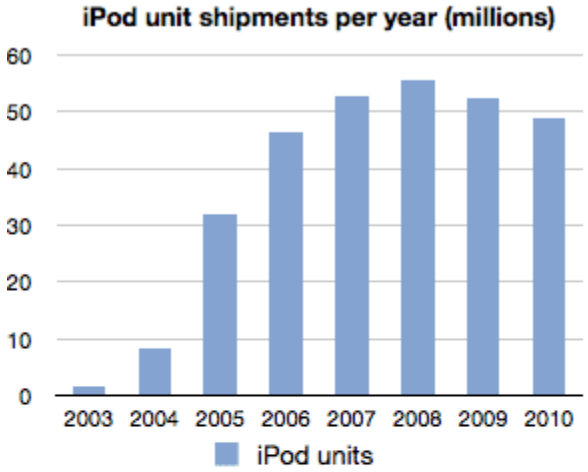
- Opportunity Cost
  - The value a resource could have provided in its best alternative use
  - Just because a project has a positive NPV that does not mean that it should also have automatic acceptance. Specifically if another project with a higher NPV would have to be passed up we should not proceed.

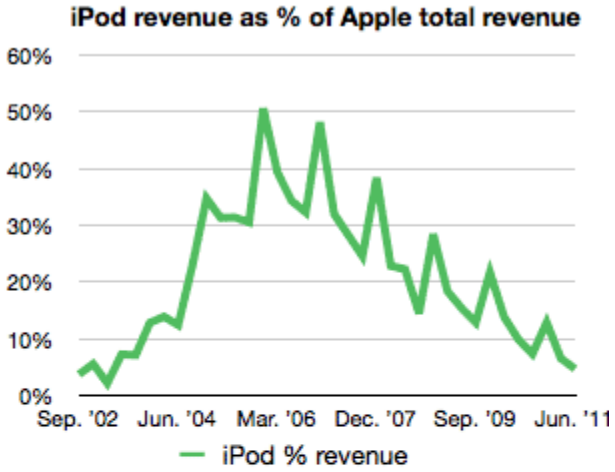
Project Externalities

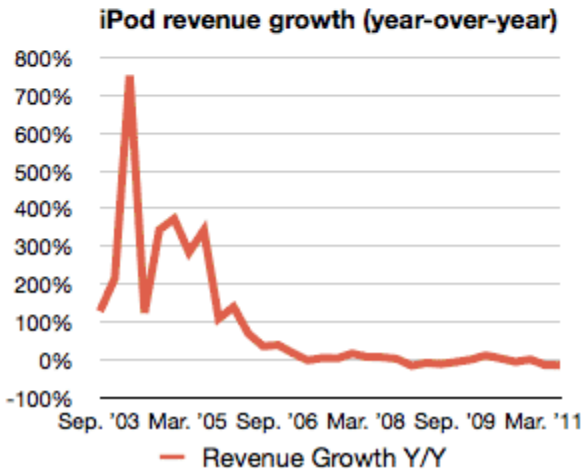
- Indirect effects of the project that may affect the profits of other business activities of the firm. **Cannibalization** is when sales of a new product displaces sales of an existing product.

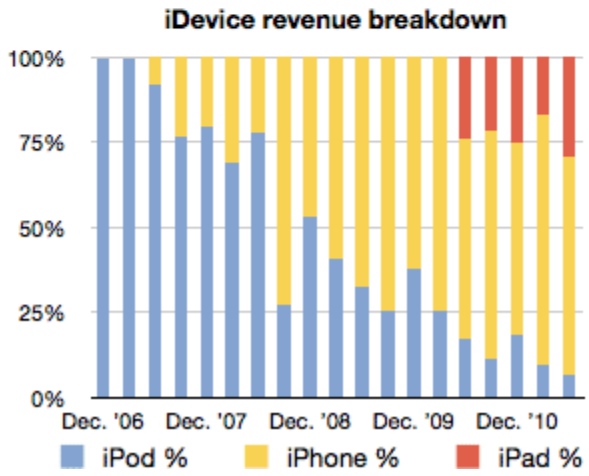
Apple's iPod business in context

SplatF









Example

Suppose that approximately 25% of HomeNet's sales come from customers who would have purchased an existing Linksys wireless router if HomeNet were not available.

	Year	0	1	2	3	4	5
Incremental Earnings Forecast ($000s)							
1	Sales	—	23,500	23,500	23,500	23,500	—
2	Cost of Goods Sold	—	(9,500)	(9,500)	(9,500)	(9,500)	—
3	**Gross Profit**	—	14,000	14,000	14,000	14,000	—
4	Selling, General, and Administrative	—	(3,000)	(3,000)	(3,000)	(3,000)	—
5	Research and Development	(15,000)	—	—	—	—	—
6	Depreciation	—	(1,500)	(1,500)	(1,500)	(1,500)	(1,500)
7	**EBIT**	(15,000)	9,500	9,500	9,500	9,500	(1,500)
8	Income Tax at 40%	6,000	(3,800)	(3,800)	(3,800)	(3,800)	600
9	**Unlevered Net Income**	**(9,000)**	**5,700**	**5,700**	**5,700**	**5,700**	**(900)**

Further Adjustments to Free Cash Flow

- Other Non-cash Items
  - Amortization
- Accelerated Depreciation（加速折旧）
  - Modified Accelerated Cost Recovery System (MACRS) depreciation

Example

Computing Accelerated Depreciation

Problem

What depreciation deduction would be allowed for the lab equipment using the MACRS method, assuming the lab equipment is designated to have a five-year recovery period?

Example

Solution

Table 7A.1 in the appendix provides the percentage of the cost that can be depreciated each year. Based on the table, the allowable depreciation expense for the lab equipment is shown below (in thousands of dollars):

	Year	0	1	2	3	4	5
MACRS Depreciation							
1	Lab Equipment Cost	(7,500)					
2	MACRS Depreciation Rate	20.00%	32.00%	19.20%	11.52%	11.52%	5.76%
3	Depreciation Expense	(1,500)	(2,400)	(1,440)	(864)	(864)	(432)

Compared with straight-line depreciation, the MACRS method allows for larger depreciation deductions earlier in the asset's life, which increases the present value of the depreciation tax shield and so will raise the project's NPV. In the case of HomeNet, computing the NPV using MACRS depreciation leads to an NPV of $5.34 million.

Example

Depreciation Example

Your firm produces titanium road bikes. You are considering buying 10 new welding stations to increase production.

- The welding stations cost $12,000 each.
- You expect that the increase in sales will raise your firm's Operating Profit (Sales - COGS - Op. Exp) by $50,000 for each year they are in use.
- Assume there will be no effect on working capital.
- Assume that welding machines are depreciated straight-line for 10 years.
- You expect to sell the machines after 5 years for $6,500 each.
- Your tax rate is 30%. Your firm's discount rate is 10%.
- What are the cash flows for the expansion? What is the NPV?

Example

$$C_t = (1-\tau)(\text{Operating Profit})_t + \tau \text{DEPR}_t - \text{CAPX}_t - \Delta \text{WC}_t$$

Date	$(1-\tau)(\text{O.P.})_t$	$+\tau\text{DEPR}_t$	$-\text{CAPX}_t$	$=C_t$	Book Value$_t$
0	0	0	−120,000	−120,000	120,000
1	0.7 ×50,000	0.3 × 12,000	0	38,600	108,000
2	0.7 ×50,000	0.3 × 12,000	0	38,600	96,000
3	0.7 ×50,000	0.3 × 12,000	0	38,600	84,000
4	0.7 ×50,000	0.3 × 12,000	0	38,600	72,000
5	0.7 ×50,000	0.3 × 12,000	63,500	102,100	60,000

$$\text{NPV} = -120,000 + \frac{\$38,600}{(1+10\%)} + \cdots + \frac{\$38,600}{(1+10\%)^4} + \frac{\$102,100}{(1+10\%)^5} = \$65,752.87$$

Example

Suppose instead that you can use the 10 year MACRS schedule for this equipment.

Date	$(1-\tau)(\text{O.P.})_t$	$+\tau\text{DEPR}_t$	$-\text{CAPX}_t$	$=C_t$	MACRS_t	BV_t
0	0	0	−120,000	−120,000	0	120,000
1	0.7×50,000	0.3×12,000	0	38,600	10%	108,000
2	0.7×50,000	0.3×21,600	0	41,480	18%	86,400
3	0.7×50,000	0.3×17,280	0	40,184	14.4%	69,120
4	0.7×50,000	0.3×13,824	0	39,147	11.52%	55,296
5	0.7×50,000	0.3×11,064	58,769.6	97,089	9.22%	44,232

$$\text{NPV} = -120,000 + \frac{\$38,600}{1.1} + \ldots + \frac{\$39,147}{1.1^4} + \frac{\$97,089}{1.1^5} = \$66,585.$$

Note the positive impact of accelerated depreciation on the NPV.

Liquidation or Salvage Value(清算或残值）

$$\text{Capital Gain} = \text{Sale Price} - \text{Book Value}$$

$$\text{Book Value} = \text{Purchase Price} - \text{Accumulated Depreciation}$$

$$\text{After-Tax Cash Flow from Asset Sale} = \text{Sale Price} - (\tau_c \times \text{Capital Gain})$$

Example

Adding Salvage Value to Free Cash Flow

Problem

Suppose that in addition to the $7.5 million in new equipment required for HomeNet's lab, equipment will be transferred to the lab from another Linksys facility. This equipment has a resale value of $2 million and a book value of $1 million. If the equipment is kept rather than sold, its remaining book value can be depreciated next year. When the lab is shut down in year 5, the equipment will have a salvage value of $800,000. What adjustments must we make to HomeNet's free cash flow in this case?

Example

Solution

The existing equipment could have been sold for $2 million. The after-tax proceeds from this sale are an opportunity cost of using the equipment in the HomeNet lab. Thus we must reduce HomeNet's free cash flow in year 0 by $2 million − 40% × ($2 million − $1 million) = $1.6 million.

In year 1, the remaining $1 million book value of the equipment can be depreciated, creating a depreciation tax shield of 40% × $1 million = $400,000. In year 5, the firm will sell the equipment for a salvage value of $800,000. Because the equipment will be fully depreciated at that time, the entire amount will be taxable as a capital gain, so the after-tax cash flow from the sale is $800,000 × (1 − 40%) = $480,000.

The spreadsheet below shows these adjustments to the free cash flow from Table 7.3 Spreadsheet and recalculates HomeNet's free cash flow and NPV in this case.

	Year	0	1	2	3	4	5
Free Cash Flow and NPV ($000s)							
1	Free Cash Flow w/o equipment	(16,500)	5,100	7,200	7,200	7,200	2,700
	Adjustments for use of existing equipment						
2	After-Tax Salvage Value	(1,600)	–	–	–	–	480
3	Depreciation Tax Shield	–	400	–	–	–	–
4	**Free Cash Flow with equipment**	**(18,100)**	**5,500**	**7,200**	**7,200**	**7,200**	**3,180**
5	**NPV at 12%**	**4,055**					

Terminal or Continuation Value(终值或持续价值)

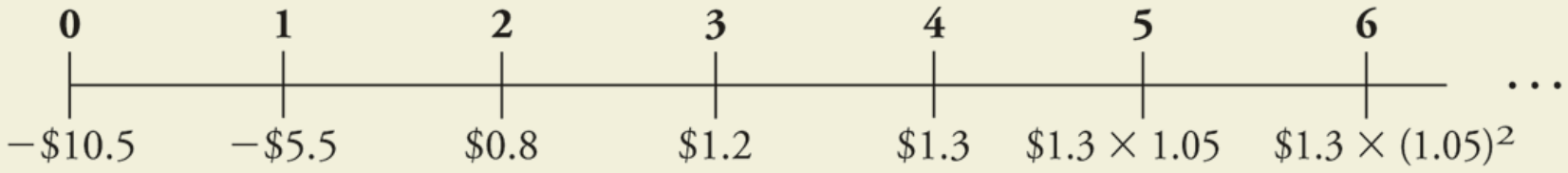
- This amount represents the market value of the free cash flow from the project at all future dates.

Example

Continuation Value with Perpetual Growth

Problem

Base Hardware is considering opening a set of new retail stores. The free cash flow projections for the new stores are shown below (in millions of dollars):



After year 4, Base Hardware expects free cash flow from the stores to increase at a rate of 5% per year. If the appropriate cost of capital for this investment is 10%, what continuation value in year 3 captures the value of future free cash flows in year 4 and beyond? What is the NPV of the new stores?

Example

Solution

The expected free cash flow from the store in year 4 is $1.30 million, with future free cash flow beyond year 4 expected to grow at 5% per year. The continuation value in year 3 of the free cash flow in year 4 and beyond can therefore be calculated as a constant growth perpetuity:

$$\text{Continuation Value in Year 3} = \text{PV(FCF in Year 4 and Beyond)}$$

$$= \frac{FCF_4}{r - g} = \frac{\$1.30 \text{ million}}{0.10 - 0.05} = \$26 \text{ million}$$

We can restate the free cash flows of the investment as follows (in thousands of dollars):

Year	0	1	2	3
Free Cash Flow (Years 0–3)	(10,500)	(5,500)	800	1,200
Continuation Value				26,000
Free Cash Flow	(10,500)	(5,500)	800	27,200

The NPV of the investment in the new stores is

$$NPV = -10{,}500 - \frac{5500}{1.10} + \frac{800}{1.10^2} + \frac{27{,}200}{1.10^3} = \$5597$$

or $5.597 million.

Tax Carryforwards(纳税递延)

- Tax loss carryforwards (递延) and carrybacks (追溯) allow corporations to take losses during its current year and offset them against gains in nearby years.

Example

Tax Loss Carryforwards

Problem

Verian Industries has outstanding tax loss carryforwards of $100 million from losses over the past six years. If Verian earns $30 million per year in pre-tax income from now on, when will it first pay taxes? If Verian earns an extra $5 million this coming year, in which year will its taxes increase?

Example

Solution

With pre-tax income of $30 million per year, Verian will be able to use its tax loss carryforwards to avoid paying taxes until year 4 (in millions of dollars):

Year	1	2	3	4	5
Pre-tax Income	30	30	30	30	30
Tax Loss Carryforward	−30	−30	−30	−10	
Taxable Income	0	0	0	20	30

If Verian earns an additional $5 million the first year, it will owe taxes on an extra $5 million in year 4:

Year	1	2	3	4	5
Pre-tax Income	35	30	30	30	30
Tax Loss Carryforward	−35	−30	−30	−5	
Taxable Income	0	0	0	25	30

Thus, when a firm has tax loss carryforwards, the tax impact of current earnings will be delayed until the carryforwards are exhausted. This delay reduces the present value of the tax impact, and firms sometimes approximate the effect of tax loss carryforwards by using a lower marginal tax rate.

Calculate NWC

Net Working Capital with Changing Sales

Problem

Forecast the required investment in net working capital for HomeNet under the scenario in Example 7.3.

Example

Solution

Required investments in net working capital are shown below:

	Year	0	1	2	3	4	5
Net Working Capital Forecast ($000s)							
1	Receivables (15% of Sales)	–	3,525	3,966	3,569	1,285	–
2	Payables (15% of COGS)	–	(1,425)	(1,603)	(1,443)	(519)	–
3	Net Working Capital	–	2,100	2,363	2,126	765	–
4	Increases in NWC	–	2,100	263	(237)	(1,361)	(765)

In this case, working capital changes each year. A large initial investment in working capital is required in year 1, followed by a small investment in year 2 as sales continue to grow. Working capital is recovered in years 3–5 as sales decline.

Calculating the NPV

$$PV(FCF_t) = \frac{FCF_t}{(1+r)^t} = FCF_t \times \underbrace{\frac{1}{(1+r)^t}}_{t = year\ discount\ factor}$$

PV：现值 (present value)
FCF：自由现金流 (free cash flow)
r：贴现率或资本成本

	Year	0	1	2	3	4	5
Incremental Earnings Forecast ($000s)							
1	Sales	—	23,500	23,500	23,500	23,500	—
2	Cost of Goods Sold	—	(9,500)	(9,500)	(9,500)	(9,500)	—
3	**Gross Profit**	—	14,000	14,000	14,000	14,000	—
4	Selling, General, and Administrative	—	(3,000)	(3,000)	(3,000)	(3,000)	—
5	Research and Development	(15,000)	—	—	—	—	—
6	Depreciation	—	(1,500)	(1,500)	(1,500)	(1,500)	(1,500)
7	**EBIT**	(15,000)	9,500	9,500	9,500	9,500	(1,500)
8	Income Tax at 40%	6,000	(3,800)	(3,800)	(3,800)	(3,800)	600
9	**Unlevered Net Income**	**(9,000)**	**5,700**	**5,700**	**5,700**	**5,700**	**(900)**
Free Cash Flow ($000s)							
10	Plus: Depreciation	—	1,500	1,500	1,500	1,500	1,500
11	Less: Capital Expenditures	(7,500)	—	—	—	—	—
12	Less: Increases in NWC	—	(2,100)	—	—	—	2,100
13	**Free Cash Flow**	**(16,500)**	**5,100**	**7,200**	**7,200**	**7,200**	**2,700**

Calculating the NPV

$$PV(FCF_t) = \frac{FCF_t}{(1+r)^t} = FCF_t \times \underbrace{\frac{1}{(1+r)^t}}_{t = year\ discount\ factor}$$

PV：现值 (present value)
FCF：自由现金流 (free cash flow)
r：贴现率或资本成本

- HomeNet NPV (discount rate = 12%)

$$NPV = -16{,}500 + 4{,}554 + 5{,}740 + 5{,}125 + 4{,}576 + 1{,}532$$
$$= 5{,}027$$

TABLE 7.5 SPREADSHEET **Computing HomeNet's NPV**

	Year	0	1	2	3	4	5
Net Present Value ($000s)							
1 Free Cash Flow		(16,500)	5,100	7,200	7,200	7,200	2,700
2 Project Cost of Capital	12%						
3 Discount Factor		1.000	0.893	0.797	0.712	0.636	0.567
4 PV of Free Cash Flow		(16,500)	4,554	5,740	5,125	4,576	1.532
5 NPV		5,027					

How to Discount the Cash Flows

- The cost of capital for the project depends on whether it is equity or debt financed

Consider three cases:

- All **equity financed**: No tax-adjustment to the cost of capital, r_E.
- All **debt financed**: Use a tax-adjusted cost of capital, $r_D(1-\tau)$.
- **Partly equity financed and partly debt financed**: Use a tax-adjusted weighted-average cost of capital of

$$\text{After-tax WACC} = r_D(1-\tau)\frac{D}{V} + r_E\frac{E}{V}$$

Case Study

The Boeing 777:
A Real-World Example

- In late 1990, the Boeing Company announced its intention to build the Boeing 777, a commercial airplane that could carry up to 390 passengers and fly 7,600 miles.
- Analysts expected the up-front investment and R&D costs would be as much as $8 billion.
- Delivery of the planes was expected to begin in 1995 and continue for at least 35 years.

Year	Units	Sales Revenue	Operating Costs	Dep.	Taxes	ΔNWC	Capital Spending	Invest-ment	Net Cash Flow
1991			$865.00	$40.00	$(307.70)		$400.00	$400.00	$(957.30)
1992			1,340.00	96.00	(488.24)		600.00	600.00	(1,451.76)
1993			1,240.00	116.40	(461.18)		300.00	300.00	(1,078.82)
1994			840.00	124.76	(328.02)		200.00	200.00	(711.98)
1995	14	$1,847.55	1,976.69	112.28	(82.08)	181.06	1.85	182.91	(229.97)
1996	145	19,418.96	17,865.45	101.06	493.83	1,722.00	19.42	1,741.42	681.74
1997	140	19,244.23	16,550.04	90.95	885.10	(17.12)	19.42	2.30	1,806.79

Net Cash Flow can be determined in three steps:

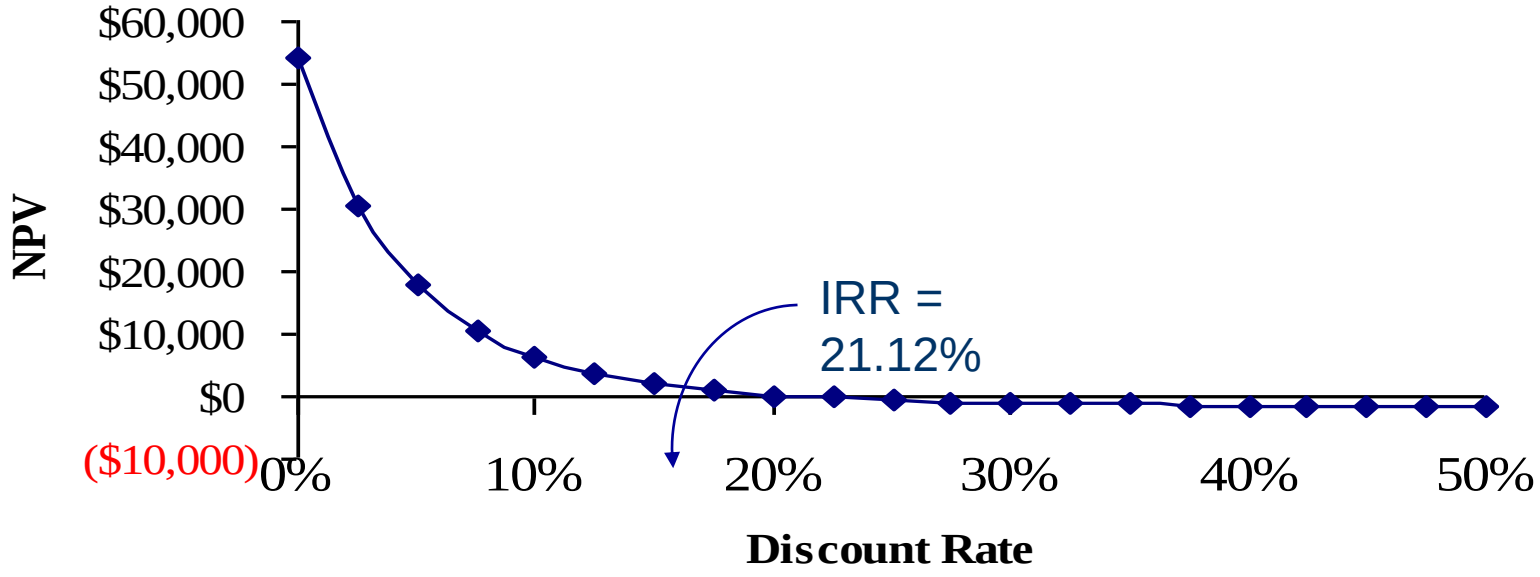
Taxes ($19,244.23 – $16,550.04 – $90.95)×0.34 = $885.10

Investment –$17.12 + $19.42 = $2.30

NCF $19,244.23 – $16,550.04 – $885.10 – $2.30 = $1,806.79

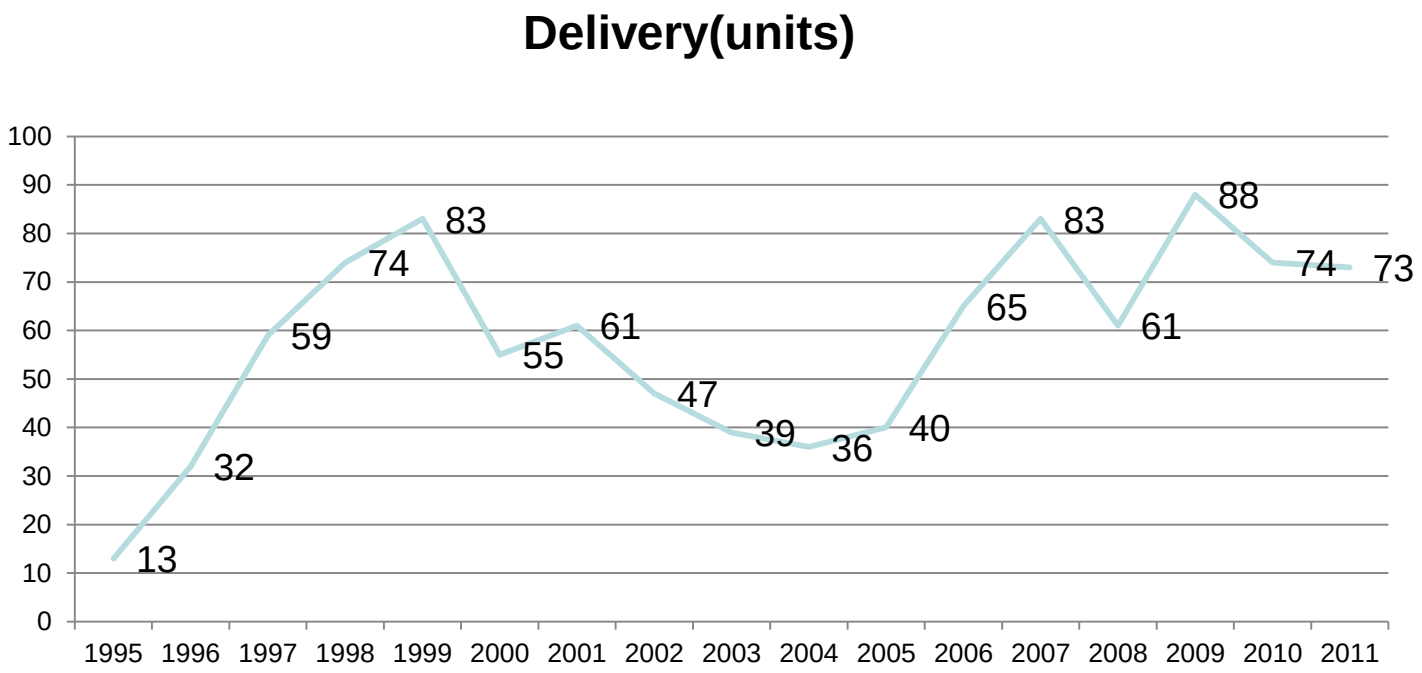
- Prior to 1990, Boeing had invested several hundred million dollars in research and development.
  - Since these cash outflows were incurred prior to the decision to build the plane, they are *sunk costs*.

Year	NCF	Year	NCF	Year	NCF
1991	$ (957.30)	2002	$ 1,717.26	2013	$ 2,213.18
1992	$ (1,451.76)	2003	$ 1,590.01	2014	$ 2,104.73
1993	$ (1,078.82)	2004	$ 1,798.97	2015	$ 2,285.77
1994	$ (711.98)	2005	$ 616.79	2016	$ 2,353.81
1995	$ (229.97)	2006	$ 1,484.73	2017	$ 2,423.89
1996	$ 681.74	2007	$ 2,173.59	2018	$ 2,496.05
1997	$ 1,806.79	2008	$ 1,641.97	2019	$ 2,568.60
1998	$ 1,914.06	2009	$ 677.92	2020	$ 2,641.01
1999	$ 1,676.05	2010	$ 1,886.96	2021	$ 2,717.53
2000	$ 1,640.25	2011	$ 2,331.33	2022	$ 2,798.77
2001	$ 1,716.80	2012	$ 2,576.47	2023	$ 2,882.44
				2024	$ 2,964.45



- This graph shows NPV as a function of the discount rate.
- Boeing should accept this project at discount rates less than 21 percent and reject the project at higher discount rates.

	Actual Delivery (units)	Forecast (units)
1995	13	14
1996	32	145
1997	59	140



Boeing 777

- As it turned out, sales failed to meet expectations.
- Most profitable model so far

Summary and Conclusions

- Cash flows matter—not accounting earnings.
- Sunk costs don't matter.
- Incremental cash flows matter.
- Opportunity costs matter.
- Side effects matter.
- Taxes matter: we want after-tax cash flows.

Evaluating NPV Estimates

- The NPV estimates are just that – estimates
- A positive NPV is a good start – now we need to take a closer look
  - Forecasting risk – how sensitive is our NPV to changes in the cash flow estimates, the more sensitive, the greater the forecasting risk
  - Sources of value – why does this project create value?
- Here are some techniques to test the robustness of your NPV calculated
  - Sensitivity analysis
  - Scenario analysis
  - Break-even analysis

Sensitivity Analysis

- Sensitivity analysis examines how sensitive a particular NPV calculation is to changes in the underlying assumptions (e.g., sales, costs).
  - Also known as "what-if" analysis
  - Requires changing a factor at a time holding everything else constant

Example : Sensitivity Analysis

- The following table presents the expected cash flow forecasts for an electrically powered Motor Scooter project; determine the NPV of the project given changes in the cash flow components using a 10% cost of capital.

(unit: million)	Year 0	Years 1–10
Investment	15.00	
Revenue		37.50
Variable cost		30.00
Fixed cost		3.00
Depreciation		1.50
Pretax profit		3.00
Tax at 50%		1.50
Net profit		1.50
Free cash flow	−15.00	3.00

Example (Con't)

- In the previous table, the expected revenue is estimated as follows:

$$\begin{aligned}\text{Revenue} &= \text{market share} \times \text{size of scooter market} \times \text{unit price} \\ &= 10\% \times 1 \text{ million} \times \$375 = \$37.5 \text{ million}\end{aligned}$$

- So, there are five underlying factors that determine the CFs of the project: market share, market size, unit price, variable cost, and fixed cost. If everything goes as expected, the NPV is 3.43M.
- For sensitivity analysis, we start with the best and worst estimates for each underlying variable.

Variable	Pessimistic	Expected	Optimistic
Market size	0.9 million	1 million	1.1 million
Market share	4%	10%	16%
Unit price	$350	$375	$380
Unit variable cost	$350	$300	$275
Fixed cost	$4 million	$3 million	$2 million

Example (Con't)

- We then set one variable at a time to its optimistic and pessimistic values, while holding the others unchanged. For example, the cash flow forecasts for optimistic market size scenario are as follows:

(unit: million)	Year 0	Years 1–10
Investment	15.00	
Revenue		41.25
Variable cost		33.00
Fixed cost		3.00
Depreciation		1.50
Pretax profit		3.75
Tax at 50%		1.88
Net profit		1.88
Free cash flow	−15.00	3.38

- The NPV of the project changes to 5.7M.

Example (Con't)

- The following table displays the positive NPVs of the project after sensitivity analysis.

Variable	Pessimistic	Expected	Optimistic
Market size	1.1	3.4	5.7
Market share	−10.4	3.4	17.3
Unit price	−4.2	3.4	5.0
Variable cost	−15.0	3.4	11.1
Fixed cost	0.4	3.4	6.5

- Value of the information
  - The most 'dangerous' variables appear to be market share and unit variable cost. Let us further investigate the impact of unit variable cost on the NPV of the project.
  - Suppose that the pessimistic value for variable cost partly reflects a 10% chance of a particular machine will not work as expected and that the operation will be performed by other methods at an extra cost of $20/unit.

Example (Con't)

- If the particular machine fails to work, the extra unit cost will reduce after-tax cash flow by 1 million:

$$\text{Units sold} \times \text{additional unit cost} \times (1\text{-tax rate}) = 0.1 \times \$20 \times 0.5$$

- It will reduce NPV by $\sum_{t=1}^{10} \frac{1}{1.10^t} = 6.1\text{million}$
- Putting NPV at 3.4M – 6.1M =-2.7M
- Suppose a 5M pretest will solve the machine's problem, it clearly pays to avoid the extra unit cost because $-0.5 + 10\% \times 6.1 = 0.11$

Scenario Analysis

- Sensitivity analysis examines what happens when only one underlying factor changes.
- However, underlying variables are often interrelated.
  - Market size exceeds expectation → demand stronger than expectation → unit price higher
  - Inflation pushes up both prices and costs
- Best case and worst case are not necessarily probable, they can still be possible

Scenario Analysis

- Scenario analysis mitigates these weaknesses and examines some alternative scenarios in which several variables change simultaneously. For example, the following scenario could apply to the scooter project:
  - Sharp rise in oil prices → your electrically powered scooter captures larger market share (extra 3%)
  - Sharp rise in oil prices → economic recession → market size shrink (by 0.2 million)
  - Sharp rise in oil prices → stimulates inflation → pushes up both prices and costs (by 15%)

Scenario Analysis

	Base case	High oil price
Market size	1 million	0.8 million
Market share	10%	13%
Unit price	$375	$431.25
Variable cost/unit	$300	$345
Fixed cost	$3 million	$3.45 million

	Cash flows, Years 1–10, Million	
	Base case	High oil price
Revenue	37.5	44.85
Variable cost	30.0	35.88
Fixed cost	3.0	3.45
Depreciation	1.5	1.50
Pretax profit	3.0	4.02
Tax at 50%	1.5	2.01
Net profit	1.5	2.01
Free cash flow	3.0	3.51
PV of cash flows	18.4	21.57
NPV	3.4	6.57

Break-even Analysis

- Another way to examine variability in our forecasts is break-even analysis. Analysis of the level of sales (or other variable) at which the company breaks even.
- Let us consider the break-even sales for which the NPV of the Scooter project equals zero.
- First, define the Equivalent Annual Cost (EAC) of the project as:

$$\text{Initial investment} = \frac{\text{EAC}}{r} \cdot \left(1 - \frac{1}{(1+r)^{10}}\right) \Rightarrow \text{EAC} = 2.44118\text{m}$$

Break-even Analysis

- The NPV break-even sales level, x, is given by

$$\text{EAC} = \Big((\text{Price} - \text{Variable cost}) \cdot x - \text{Fixed cost} \Big)(1 - \tau_c) + \text{Depr.} \times \tau_c$$

- So, the NPV break-even sales level is equal to 85,098 units.

Making A Decision

- Beware "Paralysis of Analysis"
- At some point you have to make a decision
- If the majority of your scenarios have positive NPVs, then you can feel reasonably comfortable about accepting the project
- If you have a crucial variable that leads to a negative NPV with a small change in the estimates, then you may want to forego the project

Lecture Summary

- Only incremental CFs count
  - Exclude: sunk costs, general overhead
  - Include: opportunity costs, side effects
- Calculate CFs from accounting statements
  - Interest expense
  - Capital expenditure and depreciation
  - Changes in working capital
- Risk analysis of CF forecasts
  - Sensitivity analysis
  - Scenario analysis
  - Break-even analysis