Chapter 5

Capital Budgeting

Road Map

Part A Introduction to finance.

Part B Valuation of assets, given discount rates.

- Fixed-Income securities.
- Common stocks.
- Real assets (capital budgeting).

Part C Determination of risk-adjusted discount rates.

Part D Introduction to derivatives.

Main Issues

- NPV Rule
- Cash Flow Calculations
- Alternatives to NPV Rule

1 NPV Rule

A firm's business involves capital investments (capital budgeting), e.g., the acquisition of real assets. The objective is to increase the firm's current market value. Decision reduces to valuing real assets, i.e., their cash flows.

Let the cash flow of an investment (a project) be

$$\{CF_0, CF_1, \cdots, CF_t\}.$$

Its current market value is

$$NPV = CF_0 + \frac{CF_1}{1+r_1} + \cdots + \frac{CF_t}{(1+r_t)^t}.$$

This is the increase in firm's market value by the project.

Investment Criteria:

1. For a single project, take it if and only if its NPV is positive.

2. For many *independent* projects, take all those with positive NPV.

3. For *mutually exclusive* projects, take the one with positive and highest NPV.

In order to compute the NPV of a project, we need to analyze

1. Cash flows
2. Discount rates
3. Strategic options.

We focus on cash flow here and return to discount rate (Part C) and strategic options (Part D) later.

2 Cash Flow Calculations

Main Points:

1. Use cash flows, not accounting earnings.
2. Use after-tax cash flows.
3. Use cash flows attributable to the project (compare firm value with and without the project):
   - Use incremental cash flows.
   - Forget sunk costs: bygones are bygones.
   - Include investment in working capital as capital expenditure.
   - Include opportunity costs of using existing facilities.

In what follows, all cash flows are attributable to the project.

$$\begin{aligned} CF &= \text{[Project Cash Inflows]} - \text{[Project Cash Outflows]} \\ &= \text{[Operating Revenues]} \\ &\quad - \text{[Operating Expenses without depreciation]} \\ &\quad - \text{[Capital Expenditures]} \\ &\quad - \text{[Taxes]}. \end{aligned}$$

Defining operating profit by

$$\begin{aligned} \text{Operating Profit} &= \text{Operating Revenues} \\ &\quad - \text{Operating Expenses w/o Depreciation} \end{aligned}$$

Let τ denote the "effective" tax rate. The income taxes are

$$\text{[Taxes]} = (\tau)\text{[Operating Profit]} - (\tau) \times \text{[Depreciation]}.$$

Accounting depreciation affects cash flows because it reduces the company's tax bill.

Then

$$\begin{aligned} CF &= (1-\tau)\text{[Operating Profits]} - \text{[Capital Expenditures]} \\ &\quad + (\tau)\text{[Depreciation]}. \end{aligned}$$

2.1 Use Cash Flows, Not Accounting Earnings

Example. Accounting Earnings vs. Cash Flows.

A machine purchased for \$1,000,000 with a life of 10 years generates annual revenues of \$300,000 and operating expenses of \$100,000. Assume that machine will be depreciated over 10 years using straight-line depreciation. The corporate tax rate is 40%.

Date	Accounting Earnings Before Tax	Accounting Earnings After Tax	Cash Flow After-tax
0	0	0	- 1,000,000
1	300,000 - 100,000 - 100,000 = 100,000	(1-0.4)(100,000) = 60,000	(1-0.4) (300,000-100,00) + 40,000 = 160,000
2	100,000	60,000	160,000
3	100,000	60,000	160,000
4	100,000	60,000	160,000
5	100,000	60,000	160,000
6	100,000	60,000	160,000
7	100,000	60,000	160,000
8	100,000	60,000	160,000
9	100,000	60,000	160,000
10	100,000	60,000	160,000

The accounting earnings do *not* accurately reflect the actual timing of cash flows.

2.2 Use After-tax Cash Flows

Example. Consider the following project (the cash flow is in thousands of dollars and tax rate is 50%):

Year	0	1	2	3	4	5
Invest	500					
Operating CF		0	100	300	300	300
Depreciation		100	100	100	100	100
Income		-100	0	200	200	200
Tax		-50	0	100	100	100
After-tax CF	-500	50	100	200	200	200
PV at 10%	-500	45.45	82.64	150.26	136.60	124.18

$$NPV = +39.13.$$

2.3 Investment In WC Is A Capital Expenditure

Typically, there are timing differences between the accounting measure of earnings (Sales - Cost of Goods Sold) and cash flows.

$$\text{Working Capital (WC)} = \text{Inventory} + \text{A/R} - \text{A/P}.$$

Changes in Working Capital

- Inventory: Cost of goods sold includes only the cost of items sold. When inventory is rising, the cost of goods sold understates cash outflows. When inventory is falling, cost of goods sold overstates cash outflows.

- Accounts Receivable (A/R): Accounting sales may reflect sales that have not been paid for. Accounting sales understate cash inflows if the company is receiving payment for sales in past periods.

- Accounts Payable (A/P) – conceptually the reverse of A/R.

Example. You run a chain of stores that sell sweaters. This quarter, you buy 1,000,000 sweaters at a price of \$30.00 each. For the next two quarters, you sell 500,000 sweaters each quarter for \$60.00 each. The corporate tax rate is 40%. In million dollars, your cash flows are

Date	After Tax Profit	Inventory	Cash Flow
0	0	$(1)(30) = 30$	-30
1	$(0.5)(60\text{-}30)(1\text{-}0.4) = 9$	$(0.5)(30) = 15$	$(0.5)(60) - (0.5)(60\text{-}30)(0.4) = 24$
2	$(0.5)(60\text{-}30)(1\text{-}0.4) = 9$	0	$(0.5)(60) - (0.5)(60\text{-}30)(0.4) = 24$

Note:

$$\text{Cash flow} = \text{Profit (after tax)} - \text{Change in Inventory.}$$

2.4 Use Market Valuation

Example. Reopen King Solomon's mine:

- Initial investment \$39.2 M
- Capacity 0.1 million oz for a life of 1year
- Production cost \$200 per oz
- Current gold price $P_0 = \$400$ per oz
- Forecasted gold price growth 5% by bearish manager
- Discount rate 10%.

NPV using the forecast:

$$NPV = -39.2 + \frac{(0.1)(420)}{1.10} = -\$1\text{million}.$$

However, gold pays no dividend. Thus, $P_0 = PV\,(P_1)$ and

$$\begin{aligned} NPV &= -\text{Investment} + PV(\text{Payoff})) \\ &= -39.2 + PV(0.1 \times P_1) \\ &= -39.2 + 40 = +\$0.8\text{million}. \end{aligned}$$

Use today's gold price.

Example (Gromb). MSW Inc. is considering the introduction of a new product: Turbo-Widgets (TW).

- TW were developed at an R&D cost of $1M over past 3 years
- New machine to produce TW would cost $2M
- New machine lasts for 15 years, with salvage value of $50,000
- New machine can be depreciated linearly to $0 over 10 years
- TW need to be painted; this can be done using excess capacity of the painting machine, which currently runs at a cost of $30,000 (regardless of how much it is used)
- Operating cost: $40,000 per year
- Sales: $400,000, but cannibalization would lead existing sales of regular widgets to decrease by $20,000
- Working Capital (WC): $250,000 needed over the life of the project
- Tax rate: 34%
- Opportunity cost of capital: 10%.

Question: What is the project's NPV (i.e., should MSW go ahead with the production of TW)?

1. Initial investment includes capital expenditure and WC
2. R&D expense is a sunk cost
3. Depreciation is \$2M/10 = \$0.2M for first 10 years
4. Project should not be charged for painting-machine time
5. Project should be charged for cannibalization of regular widget sales
6. Salvage value is fully taxable since the book value at the end of year 10 is \$0 (the machine cost has been fully depreciated).

The cash flows (in thousand dollars) are

Year	Cash Flow
0	- (2000+250) = -2250
1-10	(400-40-20)(1-0.34) + (200)(0.34) = 292.4
11-14	(400-40-20)(1-0.34) = 224.4
15	224.4 + (50)(1-0.34) + 250 = 507.4

$NPV = -\$57,617.$

3 Project Interaction

- Often we have to decide on more than one project.
- For mutually independent projects, we just apply the NPV rule to each one of them.
- For projects dependent of each other (e.g., mutually exclusive—accepting one rules out the others), we have to compare their NPVs.

Example. Potential demand for your product is projected to increase over time. If you start the project early, your competitors will catch up with you faster, by copying your idea. Your opportunity cost of capital is 10%. Denoting by FPV the project's NPV at the time of introduction, we have:

Year to Start	FPV	% Change in FPV	NPV
1	100	–	91
2	120	20	99
3	138	15	104
4	149	8	102

Before year 4, the return to waiting is larger that the opportunity cost of capital, 10%. As long as the growth rate of FPV remains below 10% after year 4, it is best to wait and introduce at the end of year 3.

4 Alternatives to NPV

In practice, investment rules other than NPV are also used:

- Payback Period
- Profitability Index (PI)
- Internal Rate of Return (IRR)

Firms use these rules because they were used historically and they may have worked (in combination with common sense) in the particular cases encountered by these firms.

These rules sometimes give the same answer as NPV, but in general they do not. We should be aware of their shortcomings and use NPV whenever possible.

The bottom line is:

The NPV rule dominates these alternative rules.

4.1 Payback Period

Definition: Payback period is the minimum s so that

$$CF_1 + CF_2 + \cdots + CF_s \geq -CF_0 = I_0$$

In words, s is the minimum length of time such that the sum of cash flows from a project is positive.

Decision Criterion Using Payback Period

- For independent projects: Accept if s is less than or equal to some fixed threshold t^*.
- For mutually exclusive projects: Among all the projects having $s \leq t^*$, accept the one that has the minimum payback period.

Example. Let $t^* = 3$. Consider the two independent projects with the following cash flows (in thousands):

	CF_0	CF_1	CF_2	CF_3	CF_4	CF_5	CF_6	t^*
Project 1	-100	20	40	30	10	40	60	4
Project 2	-100	10	10	80	5	10	10	3

Decision: Accept Project 2.

Problems with Payback Period

- It ignores cash flows after the payback period.
- It ignores discounting.

Example. (Continued.) Suppose that the appropriate discount rate is a constant 10% per period. Then

$$NPV_1 = 39,315 \quad \text{and} \quad NPV_2 = -7,270.$$

But we accepted project 2 and not project 1!

Discounted Payback Period

Taking into account appropriate discounting, we have the discounted payback period:

Definition: Discounted payback period is the minimum t^* so that

$$\frac{CF_1}{1+r} + \frac{CF_2}{(1+r)^2} + \cdots + \frac{CF_{t^*}}{(1+r)^{t^*}} \geq -CF_0$$

where r is the discount rate.

Problem: It still ignores the cash flows after the discounted payback period.

4.2 Internal Rate of Return (IRR)

IRR is the number that satisfies

$$0 = CF_0 + \frac{CF_1}{(1+IRR)} + \frac{CF_2}{(1+IRR)^2} + \cdots \frac{CF_t}{(1+IRR)^t}.$$

Decision Criterion Using IRR

- For independent projects: Accept a project if its IRR is greater than some fixed IRR^*, the threshold rate.
- For mutually exclusive projects: Among the projects having IRR's greater than IRR^*, accept one with the highest IRR.

Example Consider the following mutually exclusive projects:

	CF_0	CF_1	CF_2	CF_3	CF_4	CF_5	CF_6
Project 1	-100	20	40	30	10	40	60
Project 2	-100	10	10	80	5	10	10

Then, $\text{IRR}_1 = 21\%$ and $\text{IRR}_2 = 7\%$.

IRR rule leads to the same decisions as NPV if

1. Cash outflow occurs only at time 0
2. Only one project is under consideration
3. Opportunity cost of capital is the same for all periods
4. Threshold rate is set equal to opportunity cost of capital.

Problems with IRR

1. Non-existence of IRR

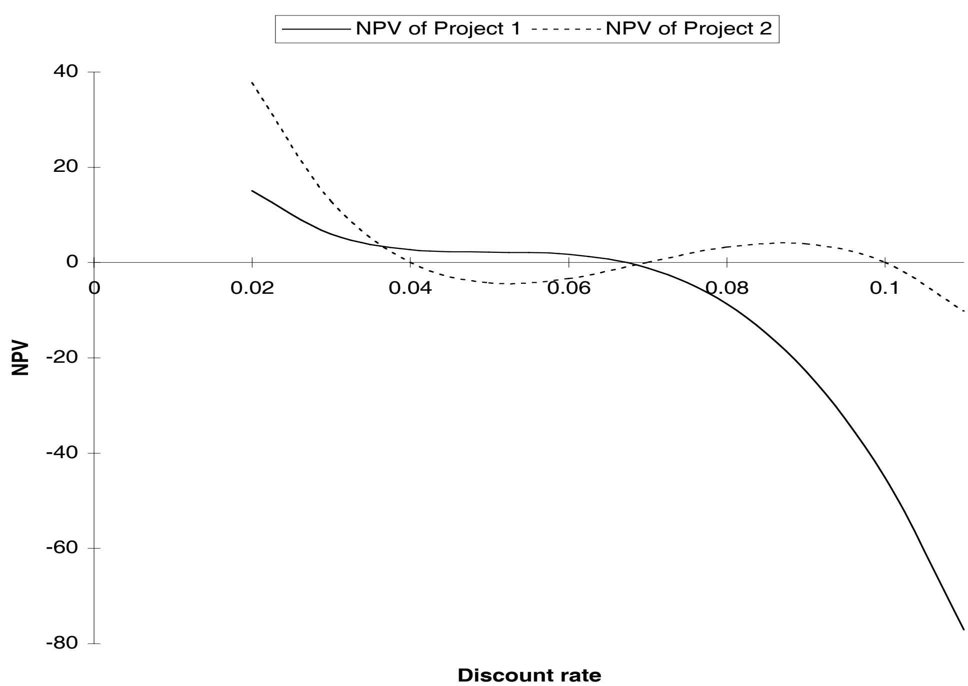
	CF_0	CF_1	CF_2
Project 1	-105	250	-150
Project 2	105	-250	150

No IRR exists for these two projects.

2. Multiple IRR's

	CF_0	CF_1	CF_2	CF_3
Project 1	-500,000	1,575,000	-1,653,750	578,815
Project 2	-500,000	1,605,000	-1,716,900	612,040

$$\text{IRR}_1 = 7\% \quad \text{and} \quad \text{IRR}_2 = \begin{cases} 4\% \\ 7\% \\ 10\% \end{cases}$$



3. Project ranking using IRR for mutually exclusive projects:

(a) Projects of different scales:

	CF_0	CF_1	IRR	NPV at 10%
Project 1	-10,000	20,000	100%	8,181.82
Project 2	-20,000	36,000	80%	12,727.27

A way around this problem is to use *incremental* CF:

- See if lower investment (project 1) is a good idea
- See if incremental investment (project 2) is a good idea.

	CF_0	CF_1	IRR	NPV at 10%
Project 1	-10,000	20,000	100%	8,181.82
Project 2	-20,000	36,000	80%	12,727.27
Project 2-1	-10,000	16,000	60%	4,545.45

(b) Projects with different time patterns of cash flows:

CF_t	0	1	2	3	4	5	ETC	IRR	NPV at 10%
Project 1	-90	60	50	40	0	0	$\cdots$	33.0%	35.92
Project 2	-90	18	18	18	18	18	$\cdots$	20.0%	90.00
Project 2-1	0	-42	-32	-22	18	18	$\cdots$	15.6%	54.08

4.3 Profitability Index

<u>Definition</u>: Profitability Index (PI) is the ratio of the present value of *future* cash flows and the initial cost of a project:

$$\mathrm{PI} = \frac{PV}{-CF_0} = \frac{PV}{I_0}.$$

Decision Criterion Using PI

- For independent projects: Accept all projects with PI greater than one (this is identical to the NPV rule)
- For mutually exclusive projects: Among the projects with PI greater than one, accept the one with the highest PI.

Problems with PI

PI gives the same answer as NPV when

(1) There is only one cash outflow, which is at time 0

(2) Only one project is under consideration.

PI scales projects by their initial investments. The scaling can lead to wrong answers in comparing mutually exclusive projects.

	CF_0	CF_1	IRR	NPV at 10%	PI at 10%
Project 1	-1,000	2,000	100%	818.18	1.82
Project 2	-2,000	3,600	80%	1,272.73	1.64
Project 2-1	-1,000	1,600	60%	454.55	1.45

4.4 The Practice of Capital Budgeting

Comparison of Methods Used by Large U.S. and Multinational Firms

	Large U.S. Firms	Multinationals	
	Percentage Using Each Method	Use as Primary Method	Use as Secondary Method
Payback Period	80.3%	5.0%	37.6%
IRR	65.5	65.3	14.6
NPV	67.6	16.5	30.0
Other	-	2.5	3.2

Historical Comparison of Primary use of
Various Capital Budgeting Techniques

	1959	1964	1970	1975	1977	1979	1981
Payback Period	34%	24%	12%	15%	9%	10%	5.0%
IRR	19	38	57	37	54	60	65.3
NPV	-	-	-	26	10	14	16.5
IRR or NPV	19	38	57	63	64	74	81.8

Source: S. Ross, R. Westerfield, and B. Jordon, *Essentials of Corporate Finance*, Irwin, 1996.)

5 Other Issues in Capital Budgeting

1. Competitive Response:
   - CF forecasts should consider responses of competitors.
2. Capital Rationing.
3. Sources of Positive-NPV Projects:
   - Short-run competitive advantage (right place at right time)
   - Long-run competitive advantage
     - patent
     - technology
     - economies of scale, etc.
   - Noise.

6 Homework

Readings:

- BMA Chapters 5, 6, 10, 11.

Assignment:

- Case write-up on capital budgeting: Acid Rain.