15.482 Healthcare Finance
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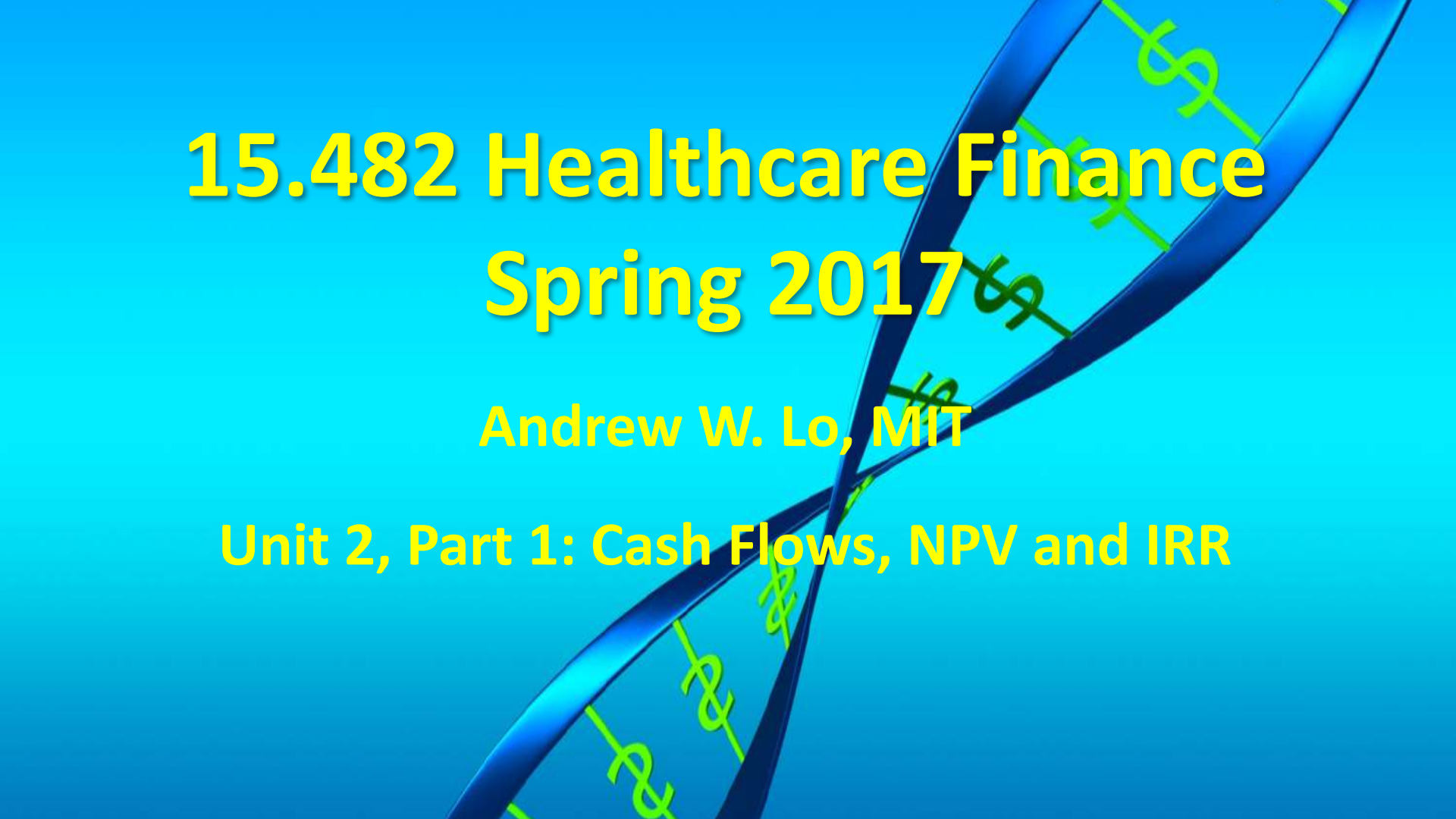
Unit 2, Part 1: Cash Flows, NPV and IRR



Unit Outline

- Capital Budgeting
- Alternatives to NPV
- Mini-Case: Genentech and Herceptin

Fundamental Challenges of Finance

Main Challenges:

- Managing cashflows (money in vs. money out) to earn attractive returns over time
- Managing risk (don't lose it all)

Managing Cash Flows:

- What to buy/sell?
- When to buy/sell it?
- How to finance it?

Capital Budgeting

Two Topics

1. **Using NPV**
   - Project's NPV
   - Cash flow estimation
   - Mini-case: LifeWorks
2. **Other Common Capital Budgeting Methods**
   - Payback period and profitability index
   - Internal rate of return (IRR)

Corporate Objective: Maximize Value

- Shareholders are the owners; management seeks to maximize shareholder wealth (stock price)
- Not the same in all countries (stakeholders vs. shareholders)
- For U.S. companies, shareholder wealth is the focus:
  - eBay Domestic Holdings Inc. v. Newmark (2010): corporate directors are bound by "fiduciary duties and standards" which include "acting to promote the value of the corporation for the benefit of its stockholders."

NPV Rule

- If companies want to increase their current market value, they should take only projects with positive NPV

$$\text{NPV} = \text{CF}_0 + \frac{\text{CF}_1}{(1+r)} + \frac{\text{CF}_2}{(1+r)^2} + \cdots + \frac{\text{CF}_T}{(1+r)^T}$$

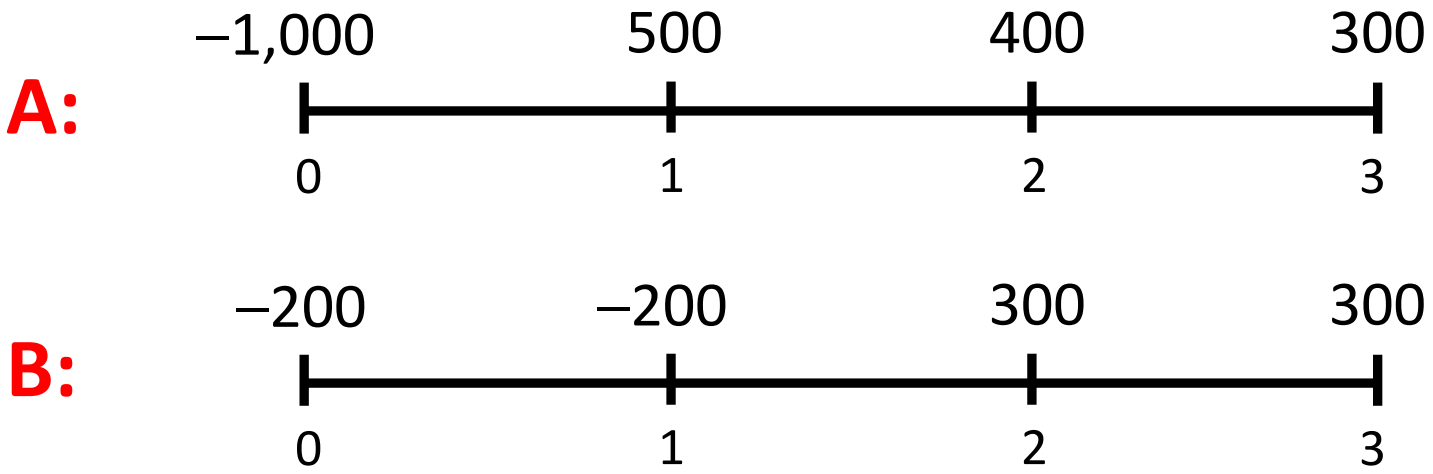
- Investment criteria:
  - For a single project, take it only if it is NPV positive
  - For many independent projects, take all those with positive NPV
  - For mutually exclusive projects, take the one with positive and highest NPV
  - For dependent projects, take the combination with the highest overall NPV

Example: Flu Vaccine

- A drug company has developed a flu vaccine and needs to choose between two strategies for full scale development. Assume r = 5%
  - Strategy A: bring to market in 1 year, invest $1 bn now and returns $500 mm, $400 mm, and $300 mm in years 1, 2, and 3, respectively
  - Strategy B: Bring to market in 2 years, invest $200 mm in years 0 and 1, and returns $300 mm in years 2 and 3

Example: Flu Vaccine

$$\text{NPV}(\text{CF}_0, \text{CF}_1, \ldots, \text{CF}_T) = \text{CF}_0 + \frac{1}{(1+r)^1}\text{CF}_1 + \cdots + \frac{1}{(1+r)^T}\text{CF}_T$$



Example: Flu Vaccine

Time	0	1	2	3
Cash Flow	-1,000.0	500.0	400.0	300.0
Present Value	-1,000.0	476.2	362.8	259.2
NPV(A)	98.2			

Time	0	1	2	3
Cash Flow	-200.0	-200.0	300.0	300.0
Present Value	-200.0	-190.5	272.1	259.2
NPV(B)	140.8			

Estimating Project Cash Flows

- Net Cash Flows = (Project Inflows) – (Project Outflows)
- Focus should be on cash flows (why?)
- However, information is often accounting data
- Accounting data is different from actual cash flows (why?)
- How to estimate NCF from accounting data?
- Brief digression on accounting (stocks vs. flows)

Brief Digression on Accounting

- Stocks vs. flows (bath tub level vs. rate of inflow of water)
- Balance sheet (stock variables):

Assets	Liabilities
Cash Capital Intangibles	Equity Debt
Value	Value

- Income statement (flow variables):

Sources of Funds = Uses of Funds

$$\Delta S + \Delta B + \text{Net Income} = \text{Investment} + \text{Dividends} + \text{Taxes} + \text{Costs}$$

Estimating Project Cash Flows

$$\begin{aligned}
\text{Net Cash Flows} &= \text{Operating Revenues} - \text{Operating Costs w/o Dep.} - \\
&\quad \text{Capital Expenditures} - \text{Income Taxes} \\
&= \text{Operating Profits} - \text{Capital Expenditures} - \\
&\quad \text{Income Taxes} \\
\text{Income Taxes} &= \tau \cdot (\text{Operating Profits}) - \tau \cdot \text{Depr.}
\end{aligned}$$

$$\begin{aligned}
\text{Net Cash Flows} &= (1-\tau)(\text{Operating Profits}) - (\text{Capital Expenditures}) + \\
&\quad \tau \cdot (\text{Depr.})
\end{aligned}$$

Cash Flows vs. Accounting Earnings

- A DNA sequencer 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 the sequencer will be depreciated over 10 years using straight-line depreciation and that the corporate tax rate is 40%

Date	Accounting earnings before taxes	Accounting earnings after taxes	Net cash flows after taxes
0	0	0	-$1,000,000
1	$300,000 - $100,000 -$100,000 = $100,000	0.6 x $100,000 = $60,000	0.6 x ($300,000 - $100,000) + $40,000 = $160,000
2	$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

Example: LifeWorks

What Is the Equity of LifeWorks Worth?

- Received FDA approval to sell arthritis drug, Relievabrex
- Number of promising candidate drugs in pipeline
- Privately held US company with no stock market price data
- 2.5 million share outstanding
- Debt with a market value of $40 million
- Cost of capital is 15% per year
- Corporate tax rate of 35%

Example: LifeWorks

Assume the following financial projections (in millions):

	Reported	Projected						
Year	0	1	2	3	4	5	6	7
Sales	100.0	108.0	116.6	126.0	136.0	146.9	158.7	171.4
Cost of goods sold	70.0	75.6	81.6	88.2	95.2	102.9	111.1	120.0
EBITDA	30.0	32.4	35.0	37.8	40.8	44.0	47.6	51.4
Capital expenditure	12.0	15.1	16.3	17.5	15.5	16.2	16.8	16.3
Depreciation	3.2	10.0	10.8	11.2	12.0	12.4	12.9	13.2
Working capital (% of sales)	16.0	17.3	18.7	20.2	21.8	23.5	25.4	27.4
ΔWorking capital		1.3	1.4	1.5	1.6	1.7	1.9	2.0

- Everything grows at 3% per year after year 7

Example: LifeWorks

Cash flow calculation:

- Taxes = 35% × (EBITDA – Depreciation)
- Cash flow = EBITDA – Capex – Taxes – ΔWorking Capital

	Reported	Projected						
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
EBITDA	30.0	32.4	35.0	37.8	40.8	44.0	47.6	51.4
Capital expenditure	12.0	15.1	16.3	17.5	15.5	16.2	16.8	16.3
Depreciation	3.2	10.0	10.8	11.2	12.0	12.4	12.9	13.2
Working capital (% of sales)	16.0	17.3	18.7	20.2	21.8	23.5	25.4	27.4
ΔWorking capital		1.3	1.4	1.5	1.6	1.7	1.9	2.0
Taxes		7.8	8.5	9.3	10.1	11.1	12.1	13.4
Cash flows		**8.2**	**8.8**	**9.5**	**13.6**	**15.0**	**16.8**	**19.7**

Example: LifeWorks

How to handle year 8 onwards:

- Compute "terminal" or "horizon" value in year 7 dollars
- Key fact: everything grows at g = 3% per year after year 7

$$\text{PV in Year 7} = \text{Cash flow in year 8} / (r - g)$$

$$= 20.3 / (0.15 - 0.03)$$

$$= \$169.2 \text{ million}$$

Example: LifeWorks

Present value of future cash flows

Year	1	2	3	4	5	6	7
Cash flows	8.2	8.8	9.5	13.6	15.0	16.8	19.7
Terminal value							169.2
Present value	**7.1**	**6.7**	**6.2**	**7.8**	**7.5**	**7.2**	**71.0**

- Value of assets = NPV(future cash flows) = $113.5 million
- Value of equity = Assets – Debt = 113.5 – 40 = $73.5 million
- Number of shares outstanding = 2.5 million

  Price per share = 73.5/2.5 = $29.40

Summary

1. **Use cash flows, not accounting earnings**
   - Accounting earning serve a different purpose than NPV calculations
2. **Use after-tax cash flows**
   - Death and taxes…
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 and in capital expenditure
   - Include opportunity costs of using existing facilities

Example: Stentorian Devices

Stentorian Devices is considering the introduction of a new stent: the TurboStent™ (TS)

- TS was developed at an R&D cost of $1M over the past 3 years
- A new machine to manufacture TS would cost $2M
- The new machine lasts for 15 years (with a commercial salvage value of $50,000) and can be depreciated linearly to $0 over 10 years
- TS needs to be coated; this can be done using excess capacity of an existing coating machine which currently runs at a cost of $30,000 (regardless of how much it is used)
- The operating cost is $40,000 per year
- The sales will be $400,000 per year, but cannibalization would cause existing sales of Stentorian's regular stents to decrease by $20,000 per year
- The working capital needed over the life of the project is $250,000
- Assume a tax rate of 34% and a discount rate of 10%

Example: Stentorian Devices

Observations:

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

Example: Stentorian Devices

NPV:

Years	Cash flow ($1000's)
0	–($2000+$250) = –$2,250.0
1-10	($400–$40–$20) x (1–0.34) + $200 x 0.34 = $292.4
11-14	($400–$40–$20) x (1-0.34) = $224.4
15	$224.4 + $50 x (1–0.34) + $250 = $507.4
NPV:	**–$57.62**

Project Interactions

Deciding Among A Set of Projects

- If projects are independent, apply NPV rule to each project
- If projects are dependent (e.g., mutually exclusive—accepting one rules out the others), we have to compare their NPVs

Optimal Timing of Projects

- Reject project
- Accept project now
- Accept project later
- Sometimes waiting can increase NPV!

Project Interactions

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 than 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.

Alternatives to NPV

Alternatives to NPV

In Practice, Other Investment Rules Are Also Used

1. Payback Period
2. Profitability Index (PI)
3. Internal Rate of Return (IRR)
4. Other techniques

Alternatives to NPV

- 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 alternatives**

Industry Practice

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The theory and practice of corporate finance: evidence from the field☆

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Abstract

We survey 392 CFOs about the cost of capital, capital budgeting, and capital structure. Large firms rely heavily on present value techniques and the capital asset pricing model, while small firms are relatively likely to use the payback criterion. A surprising number of firms use firm risk rather than project risk in evaluating new investments. Firms are concerned about financial flexibility and credit ratings when issuing debt, and earnings

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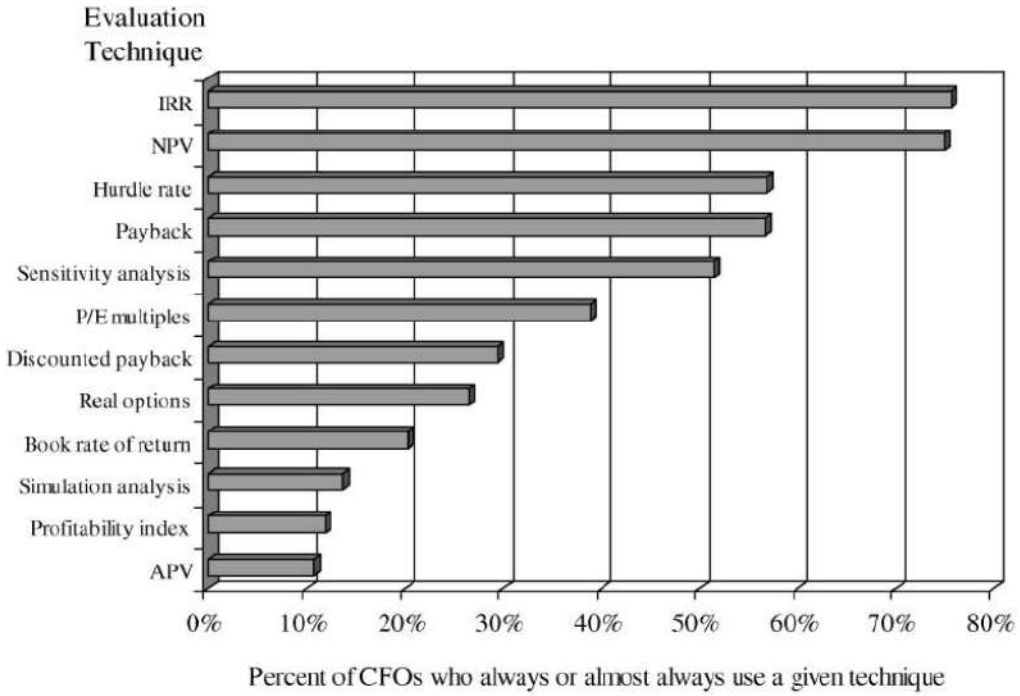
Graham and Harvey (2001) Survey of 392 CFOs



Industry Practice

Table 2
Survey responses to the question: how frequently does your firm use the following techniques when deciding which projects or acquisitions to pursue?[a]

	% always or almost always	Mean	Size		P/E		Leverage		Investment grade		Pay dividends		Industry		Management own	
			Small	Large	Growth	Non-G	Low	High	Yes	No	Yes	No	Manu.	Others	Low	High
(b) Internal rate of return	75.61	3.09	2.87	3.41***	3.36	3.36	2.85	3.36***	3.52	3.35	3.43	2.68***	3.19	2.94**	3.34	2.85***
(a) Net present value	74.93	3.08	2.83	3.42***	3.30	3.27	2.84	3.39***	3.47	3.38	3.35	2.76***	3.23	2.82***	3.35	2.77***
(f) Payback period	56.74	2.53	2.72	2.25***	2.55	2.41	2.58	2.46	2.48	2.36	2.46	2.63	2.68	2.33***	2.39	2.70**
(c) Hurdle rate	56.94	2.48	2.13	2.95***	2.78	2.87	2.27	2.63**	3.01	2.92	2.84	2.06***	2.60	2.29**	2.70	2.12***
(j) Sensitivity analysis (e.g., "good" vs. "fair" vs. "bad")	51.54	2.31	2.13	2.56***	2.35	2.41	2.10	2.56***	2.60	2.62	2.42	2.17**	2.35	2.24	2.37	2.18
(d) Earnings multiple approach	38.92	1.89	1.79	2.01*	1.97	2.11	1.67	2.12***	1.90	2.22*	1.88	1.88	1.85	2.00	1.85	2.04
(g) Discounted payback period	29.45	1.56	1.58	1.55	1.52	1.67	1.49	1.64	1.84	1.49*	1.54	1.62	1.61	1.50	1.49	1.76*
(l) We incorporate the "real options" of a project when evaluating it	26.59	1.47	1.40	1.57	1.31	1.55	1.50	1.41	1.34	1.61	1.37	1.52	1.49	1.45	1.40	1.52
(i) Accounting rate of return (or book rate of return on assets)	20.29	1.34	1.41	1.25	1.43	1.19	1.34	1.32	1.22	1.21	1.40	1.27	1.36	1.34	1.30	1.44
(k) Value-at-risk or other simulation analysis	13.66	0.95	0.76	1.22***	0.84	0.86	0.78	1.10***	1.09	1.04	1.04	0.82**	0.95	0.92	0.95	0.86
(e) Adjusted present value	10.78	0.85	0.93	0.72*	0.97	0.69**	0.87	0.80	0.80	0.79	0.80	0.91	0.78	0.92	0.79	0.99*
(h) Profitability index	11.87	0.83	0.88	0.75	0.73	0.81	0.74	0.96*	0.66	0.67	0.81	0.83	0.90	0.76	0.81	0.98

Industry Practice

	% always or almost always	Mean	CEO age		CEO tenure		CEO MBA		Regulated		Target debt ratio		Public corp.		Foreign sales		Fortune 500 mailing	
			> 59	Ynger	Long	Short	Yes	No	Yes	No	No	Yes	Yes	No	Yes	No	No	Yes
(b) Internal rate of return	75.61	3.09	3.21	3.06	2.97	3.16*	3.17	3.03	3.76	3.04***	3.03	3.18	3.27	277***	3.31	3.01**	3.00	3.57***
(a) Net present value	74.93	3.08	3.08	3.09	2.90	3.17**	3.17	3.00*	3.50	3.07**	2.99	3.23**	3.24	2.78***	3.38	2.95***	2.97	3.60***
(f) Payback period	56.74	2.53	2.83	2.43***	2.80	2.37***	2.48	2.55	2.05	2.56**	2.65	2.43*	2.45	2.67*	2.62	2.49	2.57	2.35
(c) Hurdle rate	56.94	2.48	2.88	2.38***	2.39	2.51	2.57	2.42	3.18	2.42**	2.33	2.64**	2.70	2.10***	2.56	2.43	2.30	3.28***
(j) Sensitivity analysis (e.g., "good" vs. "fair" vs. "bad")	51.54	2.31	2.20	2.36	2.20	2.37	2.41	2.25	3.14	2.26***	2.24	2.43	2.37	2.18	2.36	2.28	2.22	2.76***
(d) Earnings multiple approach	38.92	1.89	2.25	1.79**	1.93	1.86	1.98	1.86	1.62	1.90	1.85	1.96	2.08	1.56***	1.98	1.84	1.83	2.15*
(g) Discounted payback period	29.45	1.56	1.94	1.48***	1.72	1.46*	1.68	1.49	1.52	1.60	1.57	1.61	1.56	1.60	1.62	1.53	1.51	1.84*
(l) We incorporate the "real options" of a project when evaluating it	26.59	1.47	1.68	1.40*	1.56	1.36	1.49	1.39	0.95	1.48*	1.44	1.46	1.40	1.59	1.53	1.43	1.44	1.57
(i) Accounting rate of return (or book rate of return on assets)	20.29	1.34	1.49	1.33	1.39	1.34	1.42	1.29	1.76	1.30*	1.30	1.39	1.31	1.43	1.27	1.38	1.36	1.26
(k) Value-at-risk or other simulation analysis	13.66	0.95	1.07	0.90	0.92	0.93	0.99	0.88	1.76	0.89*	0.77	1.12***	0.89	1.01	0.90	0.96	0.86	1.36***
(e) Adjusted present value	10.78	0.85	1.18	0.75***	0.88	0.80	0.74	0.91*	0.67	0.86	0.88	0.81	0.83	0.90	0.74	0.89	0.86	0.80
(h) Profitability index	11.87	0.83	0.87	0.83	0.95	0.77*	0.83	0.85	0.57	0.85	0.75	0.99**	0.76	1.00**	0.81	0.83	0.85	0.75

[a]Respondents are asked to rate on a scale of 0 (never) to 4 (always). We report the overall mean as well as the % of respondents that answered 3 (almost always) or 4 (always). ***, **, * denotes a significant difference at the 1%, 5%, and 10% level, respectively. All table columns are defined in Table 1.

Internal Rate of Return (IRR)

IRR Defined By Solution To:

$$I_0 = \frac{\text{CF}_1}{(1+\text{IRR})} + \frac{\text{CF}_2}{(1+\text{IRR})^2} + \cdots + \frac{\text{CF}_T}{(1+\text{IRR})^T}$$

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

Internal Rate of Return (IRR)

IRR Rule Leads To The Same Decisions As NPV If

1. There is only one cash outflow, which occurs at time 0
2. Only one project is under consideration
3. The opportunity cost of capital is the same for all periods
4. The threshold rate is set equal to opportunity cost of capital

Internal Rate of Return (IRR)

Shortcomings:

- Non-existent or multiple IRRs in certain cases
- Incorrect rankings for loans and other projects with negative cashflows in future periods
- Ignores scale

⇒ **Use NPV!**

Internal Rate of Return (IRR)

Example: incorrect ranking for loans

- The IRR of both projects is 20%
- If actual opportunity cost is 10%, IRR says to accept both projects
- However,
  - Project 1 has a positive NPV only if $R < 20\%$
  - Project 2 has a positive NPV only if $R > 20\%$
- Should take project 1 and reject project 2

	CF_0	CF_1
Project 1	−100	120
Project 2	100	−120

Internal Rate of Return (IRR)

Example: non-existent IRRs

	0	1	2
Project 1	−105	250	−150
Project 2	105	−250	150

- No IRR exists for these two projects

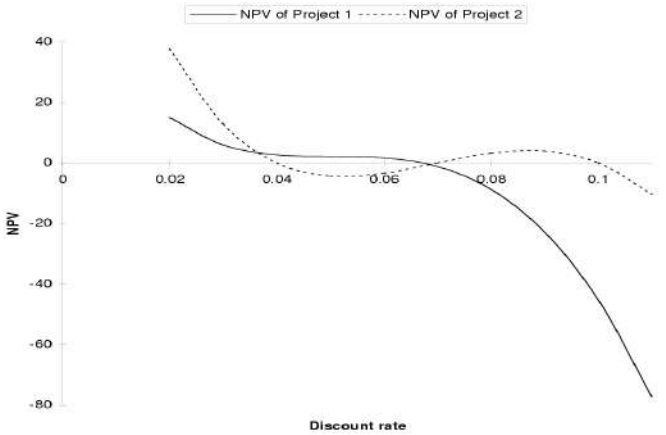
Internal Rate of Return (IRR)

Example: multiple IRRs

	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

$$IRR_1 = 7\%$$

$$IRR_2 = \begin{cases} 4\% \\ 7\% \\ 10\% \end{cases}$$



Internal Rate of Return (IRR)

Example: incorrect ranking 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

One workaround to this problem is to use **incremental** cashflows:

- 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

Internal Rate of Return (IRR)

Example: incorrect ranking for mutually exclusive projects

b) Projects with different time pattern of cash flows:

CF_t	0	1	2	3	4	5	etc.	IRR	NPV at 10%
Project 1	−90	60	50	40	0	0	···	33%	35.92
Project 2	−90	18	18	18	18	18	···	20%	90.00
Project 2−1	0	−42	−32	−22	18	18	···	15.6%	54.08

⇒ Use NPV!

Internal Rate of Return (IRR)

IRR Still Used For Venture Capital

- A single “raise” at the start; multiple “exits” as companies are sold or IPO’ed
- Each exit is typically a single payoff, hence IRR makes sense and is easy to compute
- Another measure is “cash-on-cash”, a profitability index (2.5x, 4x, etc.)

Other Issues in Capital Budgeting

1. Competitive response
   - CF forecasts should take into account 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