Week 8: FNCE10002 Principles of Finance

THE UNIVERSITY OF MELBOURNE

Capital Budgeting I

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8. Capital Budgeting I

1. Explain the capital budgeting process
2. Define, use and interpret the net present value
3. Define, use and interpret internal rate of return
4. Outline the problems with the internal rate of return method
5. Compare the *NPV* and *IRR* methods and examine the incremental *IRR* method
6. Analyze projects with resource constraints
7. Examine the payback period method and its drawbacks

Required Readings: Weeks 8 – 9

- *Week 8*
  - GRAH, Ch. 9 (skip Sec 9.3)
- *Week 9*
  - GRAH, Ch. 10 and Ch. 11

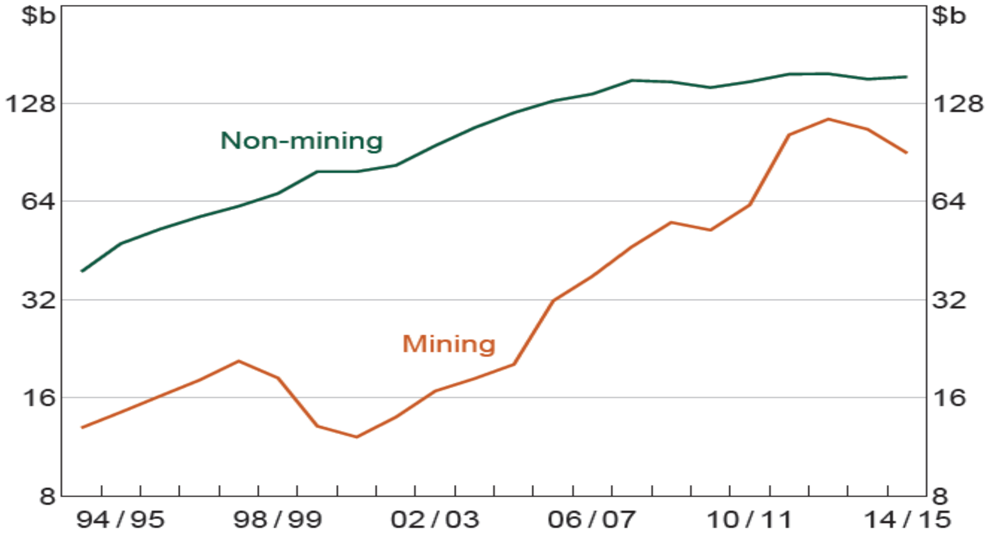
8.1 The Capital Budgeting Process

- The capital budgeting process involves the following main steps…
- Generation of investment proposals
- Evaluation and selection of investment proposals
- Approval and control of capital expenditures
- Post-completion audit of investment projects
- *Our focus is on the evaluation and selection of investment proposals*

Methods of Project Evaluation

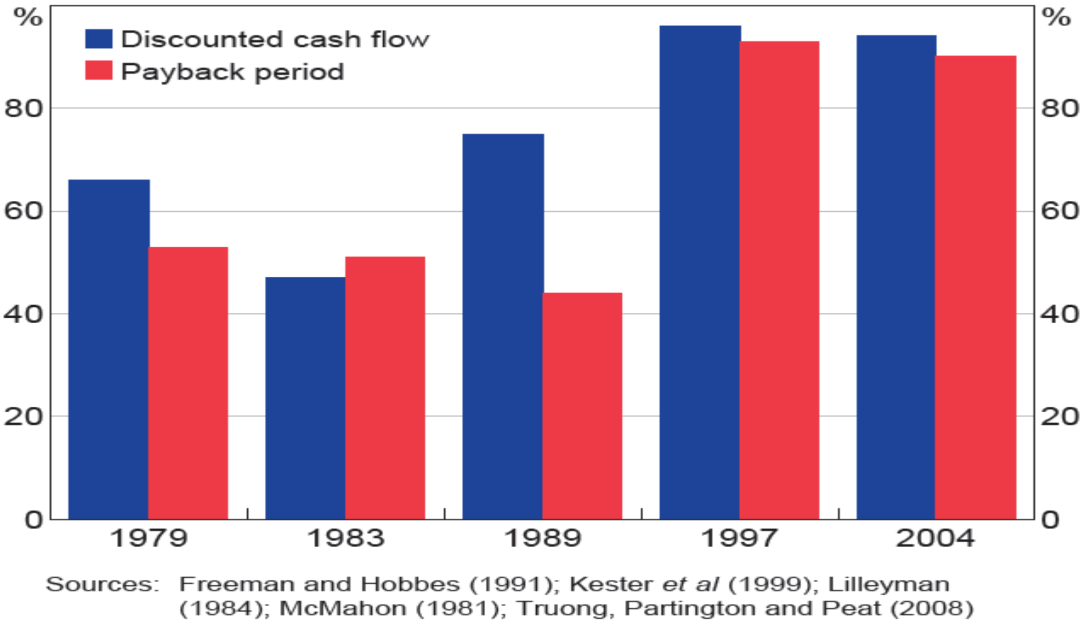
- The main methods used by managers to evaluate projects are…
  - Net present value
  - Internal rate of return
  - Payback period (discounted payback period)
  - Accounting rate of return
- *Our focus is on the net present value and internal rate of return methods*

Corporate Investment in Australia



Source: Lane and Rosewall (2015), "Firms' Investment Decisions and Interest Rates", *RBA Bulletin, Graph 1*. Corporate investments in mining and non-mining sectors between 1994-95 and 2014-15 in billions of dollars.

Capital Budgeting Decisions in Australia



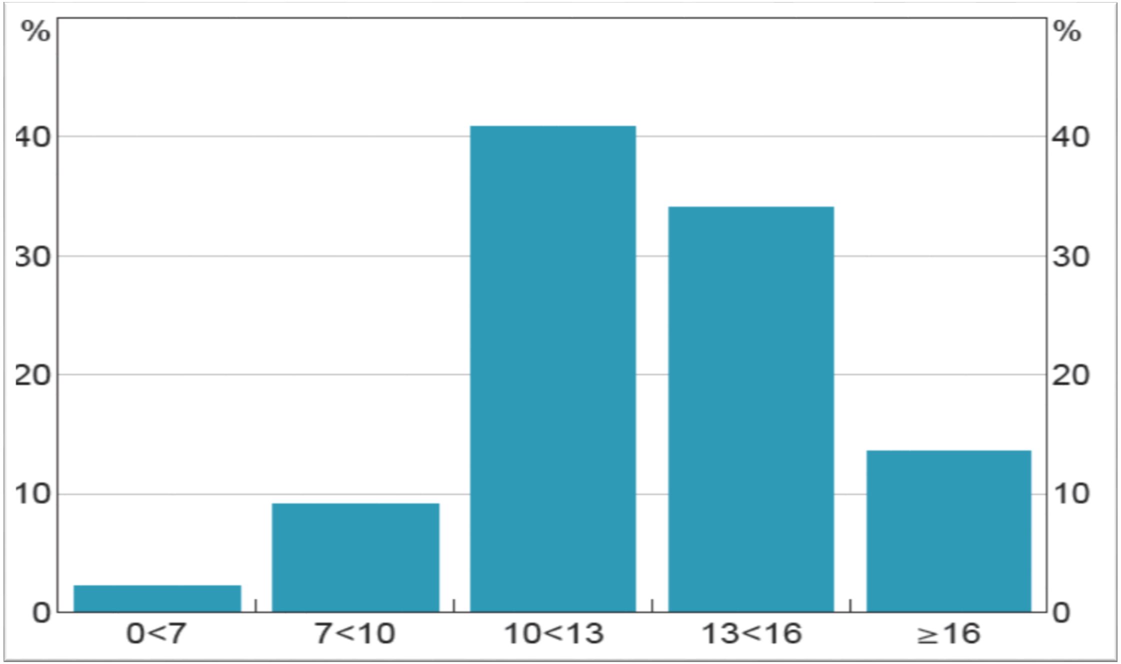
Source: Lane and Rosewall (2015), "Firms' Investment Decisions and Interest Rates", *RBA Bulletin, Graph 2*. Capital budgeting methods used in Australia.

Capital Budgeting Decisions in the US

Method Used "Always" or "Almost Always"	*Percentage*
Internal rate of return	75.6%
Net present value	74.9%
Payback period	56.7%
Accounting rate of return	20.3%
Profitability index	11.9%

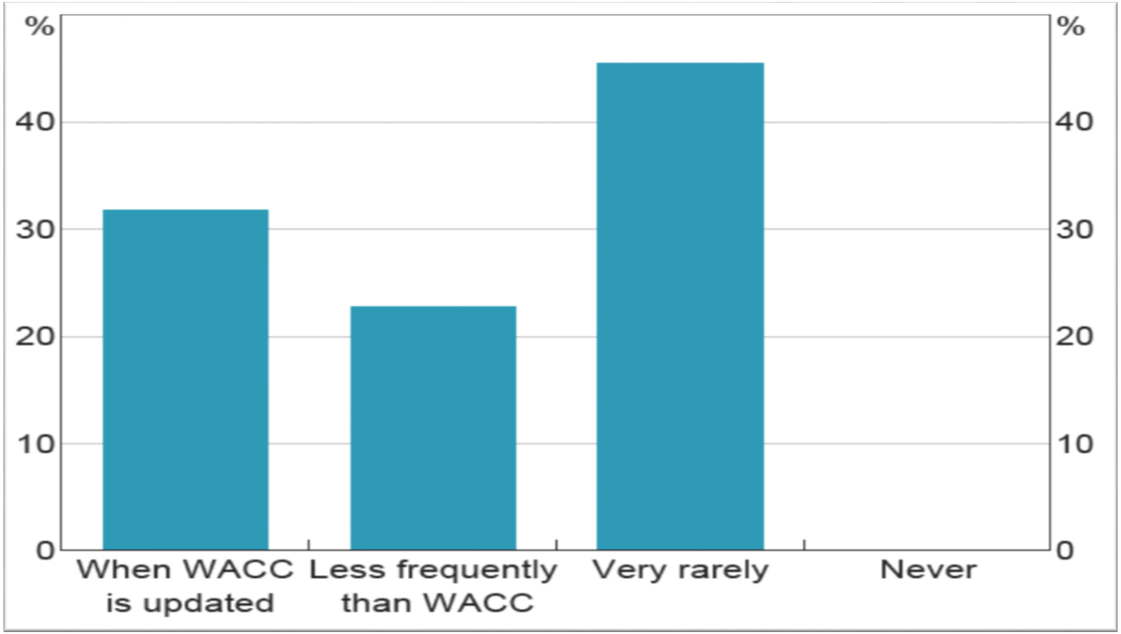
Source: Graham and Harvey (2001), "The Theory and Practice of Corporate Finance: Evidence From the Field", *Journal of Financial Economics*. Based on survey of 392 US-based CFOs. The aggregate percentage exceeds 100 percent because most respondents used more than one method of project evaluation.

Hurdle Rates Used in Investment Decisions



Source: Lane and Rosewall (2015), “Firms’ Investment Decisions and Interest Rates”, *RBA Bulletin, Graph 3*. Range of hurdle rates used in Australia.

Changes in Hurdle Rates Over Time



Source: Lane and Rosewall (2015), "Firms' Investment Decisions and Interest Rates", *RBA Bulletin, Graph 4*. Changes in hurdle rates used in Australia over time.

8.2 The Net Present Value Method

- The net present value (*NPV*) method involves…
  - Calculating the difference between the present value of the net cash flows from an investment and the initial investment outlay
  - All cash flows are discounted at the *required rate of return* which reflects the project's risk
- Project's net cash flows
  - Identify the size and timing of *incremental cash flows* as a result of the project
  - Incremental cash flows are the cash flows earned by the firm if the project *is* undertaken *minus* cash flows earned by the firm if the project is *not* undertaken
  - Net cash flows *after* corporate taxes need to be evaluated
  - Examined in detail next week

The Net Present Value Method

- The net present value is calculated as…

$$NPV = \frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_N}{(1+r)^N} - I_0$$

$$NPV = \sum_{t=1}^{N} \frac{C_t}{(1+r)^t} - I_0$$

  - I_0 = Initial investment
  - C_t = Net after-tax cash flow at the end of year t
  - r = Project's required rate of return (or discount rate)
  - N = Economic life of the project in years
  - *Note:* The text uses CF_0 for I_0 and CF_t for C_t
- *Decision:* Accept project if $NPV > 0$, reject if $NPV < 0$
  - *Note:* Point of indifference when $NPV = 0$

The Net Present Value Method

- *Example:* The net after-tax cash flows from a four-year project that costs $1 million are as follows. Evaluate the project using the net present value method assuming that the project's required rate of return is 12% p.a. How does your decision change if the initial investment were $1,300,000 and not $1,000,000?

End of Year	*Net Cash Flows*
0	–$1,000,000
1	$400,000
2	$460,000
3	$400,000
4	$340,000

The Net Present Value Method

- The project's net present value is…

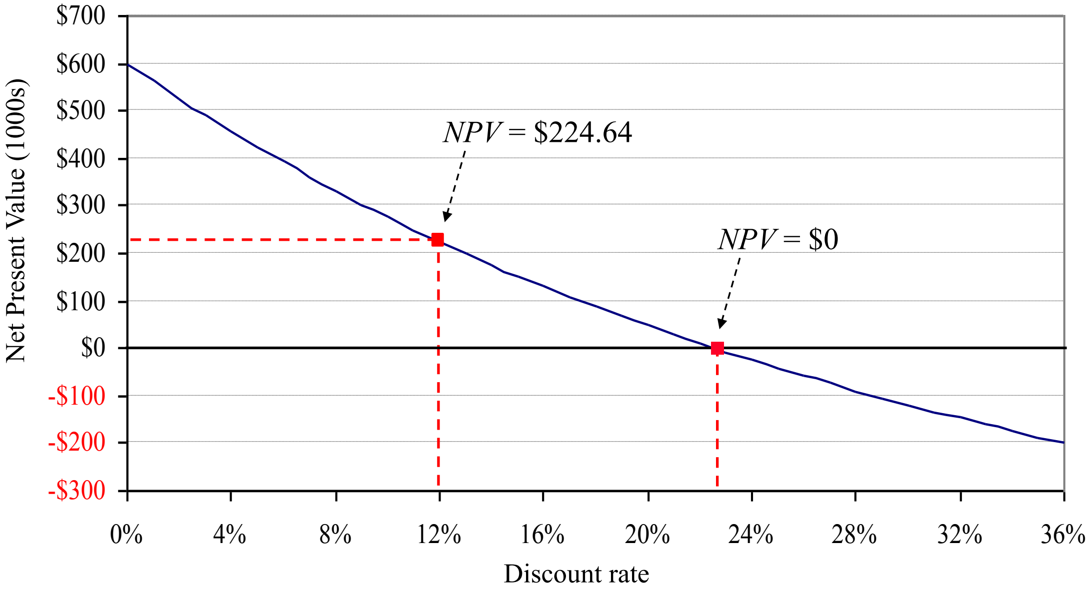
$$NPV = \frac{400}{1.12} + \frac{460}{1.12^2} + \frac{400}{1.12^3} + \frac{340}{1.12^4} - 1000 = \$224.64$$

- Since the *NPV* is positive the project should be accepted
- If the initial investment was $1,300,000 the revised *NPV* is…

$$NPV = \frac{400}{1.12} + \frac{460}{1.12^2} + \frac{400}{1.12^3} + \frac{340}{1.12^4} - 1300 = -\$75.36$$

- How does one interpret the net present value of a project?

The Net Present Value Profile



NPV and the Firm's Share Price

- *Illustration:* ASL Enterprises has 10 million shares outstanding with a current market price of $10 per share. There is one investment available to ASL whose cash flows are given below for two alternative scenarios. ASL uses a discount rate of 10% to evaluate its investments. What's the expected impact on ASL's firm value and share price in each case if capital markets fully reflect the value of undertaking the project?

End of Year	*Case 1*	*Case 2*
0	–$10,000,000	–$10,000,000
1	$4,000,000	$3,000,000
2	$4,000,000	$3,000,000
3	$4,000,000	$2,000,000
4	$4,000,000	$1,000,000
5	$4,000,000	$1,000,000

NPV and the Firm's Share Price

- The *NPV*s is each case are…

	Case 1	*Case 2*
NPV	$5,163,147	–$1,986,824

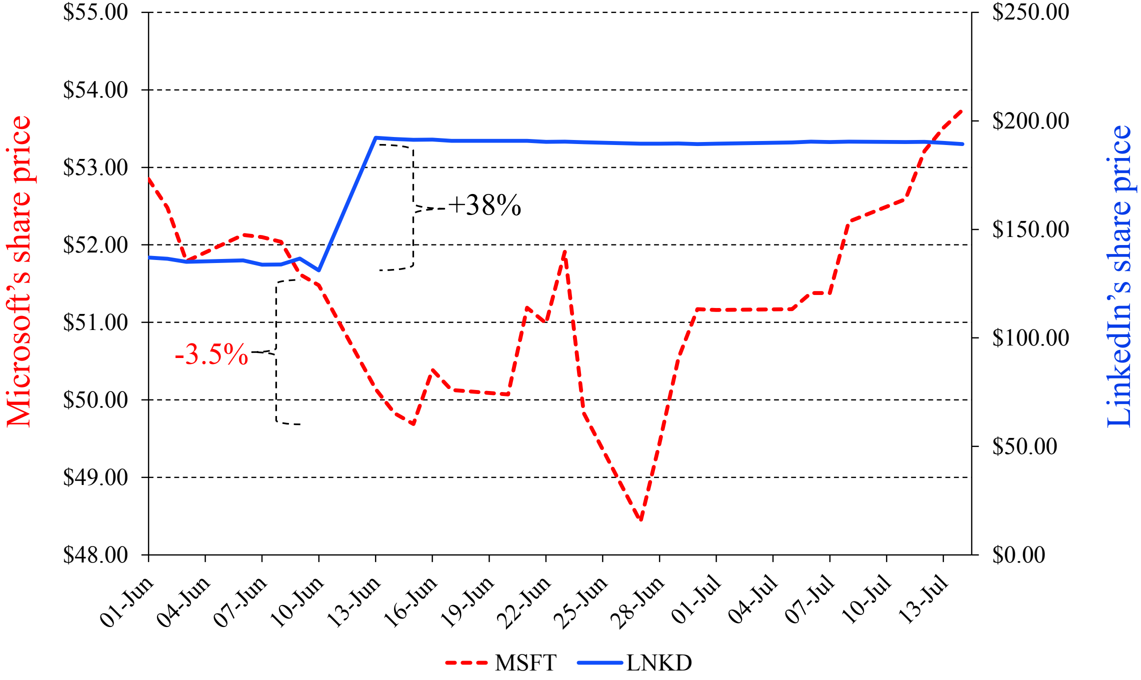
- Total firm value *before* investment = 10 × 10 = $100 million
- *Case 1*
  - Total firm value = 100 + 5.163 = $105.163 million
  - Share price = (100 + 5.163)/10 = $10.52 > $10.00
- *Case 2*
  - Total firm value = 100 – 1.986 = $98.014 million
  - Share price = (100 – 1.986)/10 = $9.80 < $10.00
- *How does the market interpret (potentially) positive and negative NPV decisions?*

Case Study: Market's Interpretation of NPV

- *June 13, 2016:* Microsoft Corp. (*Nasdaq:* MSFT) announced a US$26.2 billion takeover of the professional social network LinkedIn Corp. *Microsoft will pay $196 per share in an all-cash transaction, including LinkedIn's net cash, a 49.5 percent premium to LinkedIn's closing price Friday*. *The price relative to LinkedIn's earnings makes the transaction the most expensive of any major deal this year*, according to data compiled by Bloomberg. "This is about the coming together of the leading professional cloud and the leading professional network," Nadella said in an interview. "This is the logical next step to take. We believe we can accelerate that by making LinkedIn the social fabric for all of Office."

Source: http://www.bloomberg.com/news/articles/2016-06-13/microsoft-to-buy-linkedin-in-deal-valued-at-26-2-billion

Case Study: Market's Interpretation of NPV



8.3 Internal Rate of Return

- The internal rate of return (*IRR*) is the rate of return that is earned by the project over its economic life
  - What reinvestment rate is assumed in calculating the *IRR*?
- Set *NPV* equal to 0 and calculate the internal rate of return (*IRR*)

$$NPV = 0 = \frac{C_1}{(1+IRR)} + \frac{C_2}{(1+IRR)^2} + \ldots + \frac{C_N}{(1+IRR)^N} - I_0$$

$$NPV = 0 = \sum_{t=1}^{N} \frac{C_t}{(1+IRR)^t} - I_0$$

- *Decision:* Accept project if $IRR > r$, reject if $IRR < r$
  - *Note:* Point of indifference when $IRR = r$

Internal Rate of Return

- *Example:* Consider a project which involves an initial investment of \$100,000 and yields a net cash flow of \$150,000 at the end of year 4. What is the *IRR* of this project? What will happen to the *IRR* if all cash flows are doubled?
- Calculate the *IRR* by setting the *NPV* to zero and solving for the *IRR* in…

$$NPV = 0 = \frac{150000}{(1+IRR)^4} - 100000$$

$$IRR = \left(\frac{150000}{100000}\right)^{1/4} - 1 = 10.7\%$$

- *Note:* The *IRR* does not change with the scale of the project

Internal Rate of Return

- *Example:* The net cash flows from a four-year project that costs \$1,000,000 are as follows. Evaluate the project using the internal rate of return method and assuming that the project's required rate of return is 12% p.a.

End of Year	*Net Cash Flows*
0	–\$1,000,000
1	\$400,000
2	\$460,000
3	\$400,000
4	\$340,000

Internal Rate of Return

- *Recall:* The net present value is of the project was…

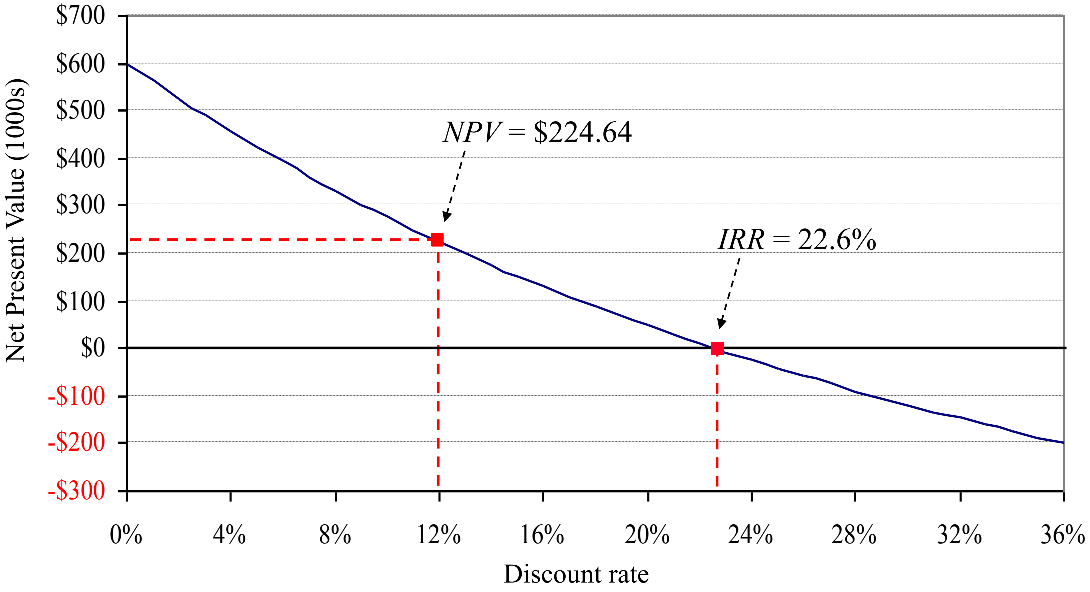
$$NPV = \frac{400}{1.12} + \frac{460}{1.12^2} + \frac{400}{1.12^3} + \frac{340}{1.12^4} - 1000 = \$224.64$$

- Internal rate of return is obtained by solving for *IRR* in…

$$NPV = 0 = \frac{400}{(1+IRR)} + \frac{460}{(1+IRR)^2} + \frac{400}{(1+IRR)^3} + \frac{340}{(1+IRR)^4} - 1000$$

  - At $IRR = 22\%$, $NPV = \$10.68$
  - At $IRR = 23\%$, $NPV = -\$7.25$
  - At $IRR = 22.5\%$, $NPV = \$1.65 \approx \$0$
  - Actual $IRR = 22.6\% > r = 12\%$
- Both rules give the *same* decision for *individual* projects

Internal Rate of Return



8.4 Problems with the IRR Method

- *Problem 1: Delayed investments, which are situations where net cash outflows follow net cash inflows*
  - *Note:* The text refers to this as the "lending versus borrowing" problem
- *Example:* Assume you have just retired as the CEO of a successful company. A major publisher has offered you a book deal. The publisher will pay you $1 million upfront if you agree to write a book about your experiences. You estimate that it will take three years to write the book. The time you spend writing will cause you to give up speaking engagements amounting to $500,000 per year. What is the book deal's internal rate of return? If your required rate of return is 10% p.a. should you accept the book deal? How does your decision change if your required rate of return is 28% p.a.?

Problems with the IRR Method

- The book deal's *IRR* is…

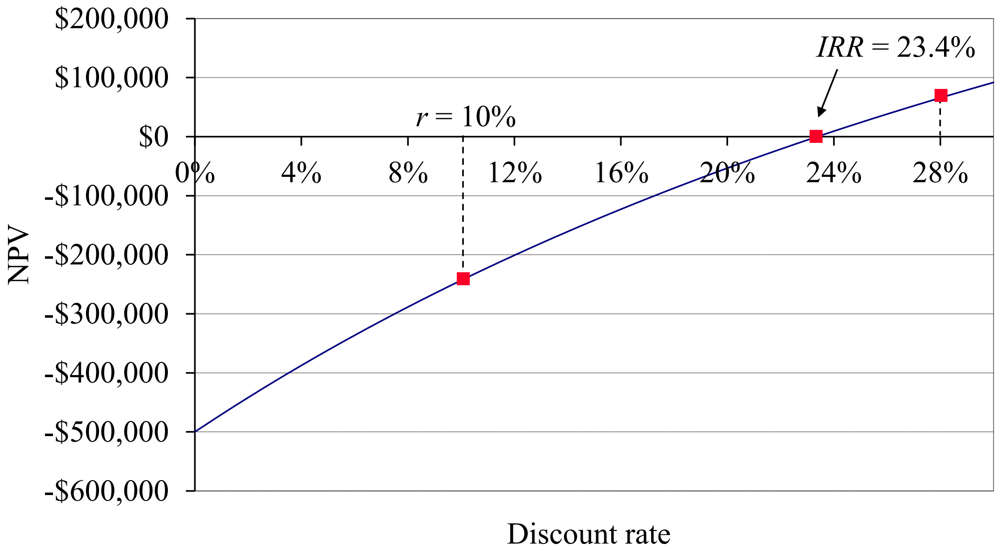
$$NPV = 0 = 1000000 - \frac{500000}{(1+IRR)} - \frac{500000}{(1+IRR)^2} - \frac{500000}{(1+IRR)^3}$$

- The *IRR* is 23.4% and is greater than the required rate of return of 10%. Based on our decision rule you should accept the book deal
- However, the book deal's net present value is…

$$NPV = 1000000 - \frac{500000}{1.10} - \frac{500000}{1.10^2} - \frac{500000}{1.10^3} = -\$243,426!$$

- The *NPV* is negative so you should *not* accept the book deal!
- What is going on here?

Problems with the IRR Method



Note: The cash flows are atypical here and the *IRR* should be interpreted as the rate being *paid* by you rather than being earned!

Problems with the IRR Method

- *Problem 2: No IRRs may exist in cases where the NPV profile never crosses the x axis*
  - The *NPV* of the project remains positive or negative no matter what discount rate is applied to the net cash flows
- *Example (continued):* In the previous example, assume that you re-negotiate the deal and are offered $750,000 and you give up speaking engagements amounting to $500,000 per year for three years. As compensation, the publisher offers an additional $1 million when the book is published in four years' time. What is the book deal's internal rate of return? If your required rate of return is 10% p.a. should you accept the book deal now?

Problems with the IRR Method

- The project's cash flows now are…

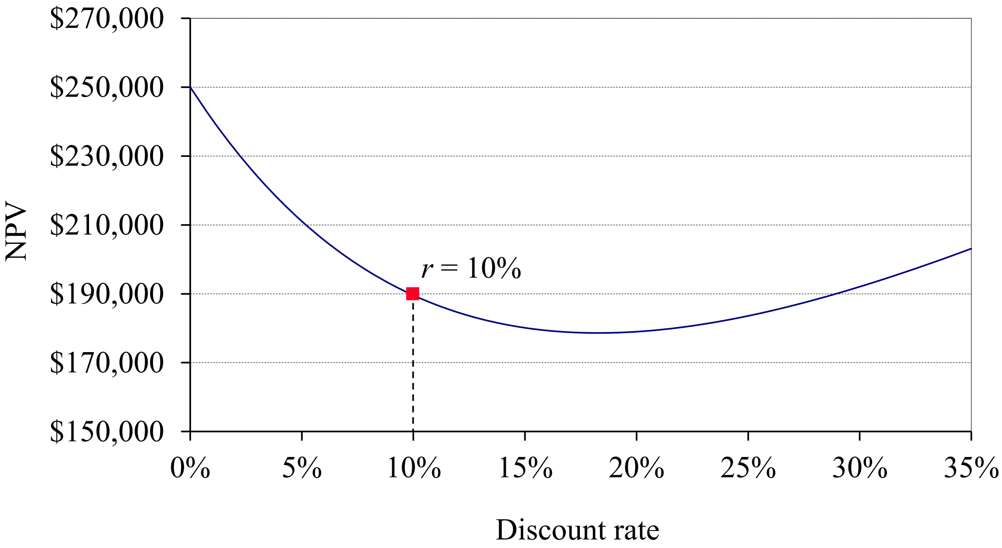
Year 0	*Year 1*	*Year 2*	*Year 3*	*Year 4*
\$750,000	–\$500,000	–\$500,000	–\$500,000	\$1,000,000

- The book deal's *IRR* is…

$$NPV = 0 = 750000 - \frac{500000}{(1+IRR)} - \frac{500000}{(1+IRR)^2} - \frac{500000}{(1+IRR)^3} + \frac{1000000}{(1+IRR)^4}$$

- There is *no* *IRR* as shown in the *NPV* profile on the next slide…

Problems with the IRR Method



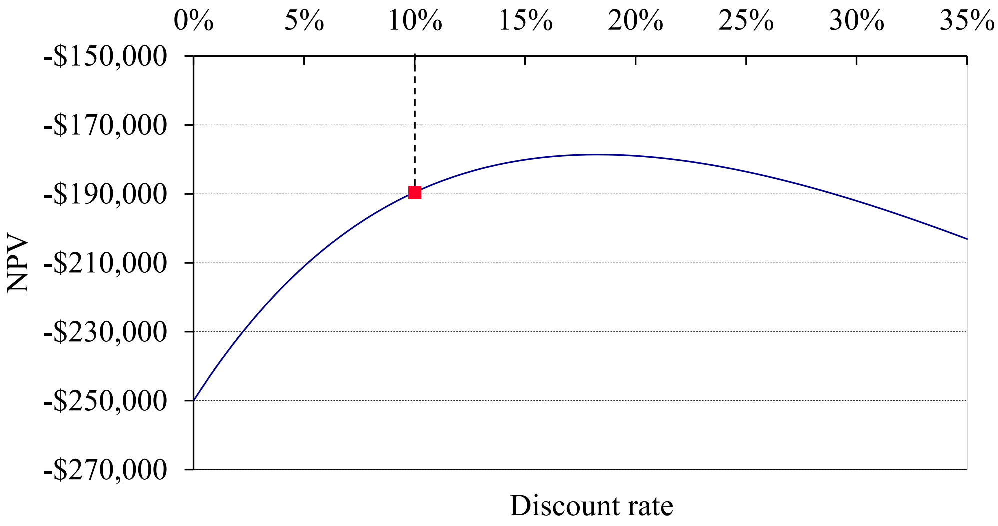
What decision would you make?

Problems with the IRR Method

- *Example:* Now consider a four-year mining project which involves an initial investment of $750,000 with cash inflows of $500,000 per year for the three years. At the end of the project there is a $1 million cash outflow related to cleaning up the mine site. What is the mine's internal rate of return? If the firm's required rate of return is 10% p.a. should the project be accepted?
- This project's cash flows are…

Year 0	*Year 1*	*Year 2*	*Year 3*	*Year 4*
–$750,000	$500,000	$500,000	$500,000	–$1,000,000

Problems with the IRR Method



What decision should the firm make?

Problems with the IRR Method

- *Problem 3: Multiple IRRs occur in circumstances where there is more than one discount rate for which the NPV of a project is equal to zero*
- A *necessary* condition for multiple *IRR*s is that there is *more* than one sign change in the future expected net cash flows
  - Note that this is *not* a *sufficient* condition!

Sign of Cash Flows	*Number of Sign Changes*	*Maximum Number of IRRs*
– + + +	1 sign change	1
+ – – –	1 sign change	1
– + + + –	2 sign changes	2
– + – + –	4 sign changes	4

Problems with the IRR Method

- *Example:* Consider a project with the following cash flows and evaluate the project using the internal rate of return method

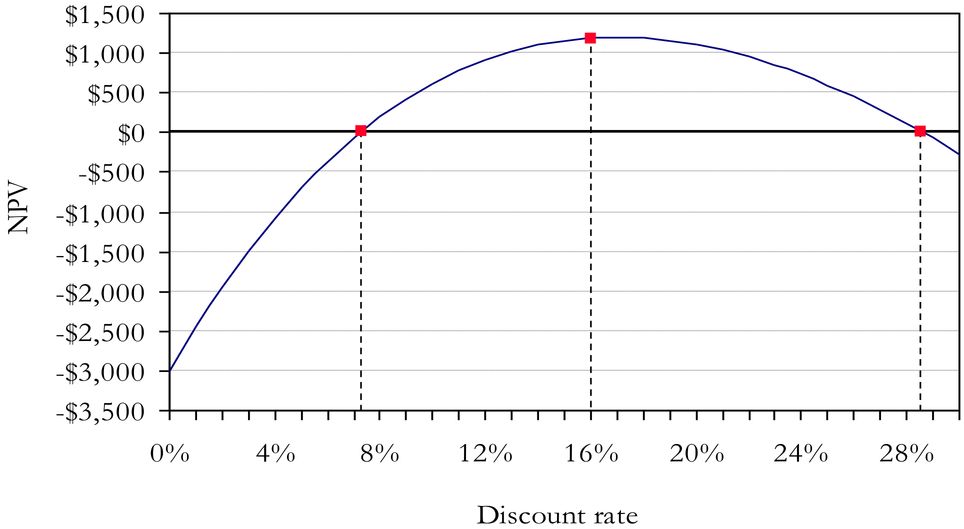
Year 0	*Year 1*	*Year 2*
–$145,000	$342,000	–$200,000

$$NPV = 0 = -145000 + \frac{342000}{(1+IRR)} - \frac{200000}{(1+IRR)^2}$$

- There are two *IRR*s (see next slide) – 7.2% and 28.6%
- Based *only* on the internal rates of return is the project acceptable if its required rate of return is 16% (that is, it lies between 7.2% and 28.6%)?

Problems with the IRR Method

$$NPV = 0 = -145000 + \frac{342000}{(1+IRR)} - \frac{200000}{(1+IRR)^2}$$



Is the project acceptable if its required rate of return is 16% (that is, it lies between 7.2% and 28.6%)?

Problems with the IRR Method

- *Example (continued):* Now consider a project with the following pattern of cash flows. Evaluate the project using the internal rate of return method

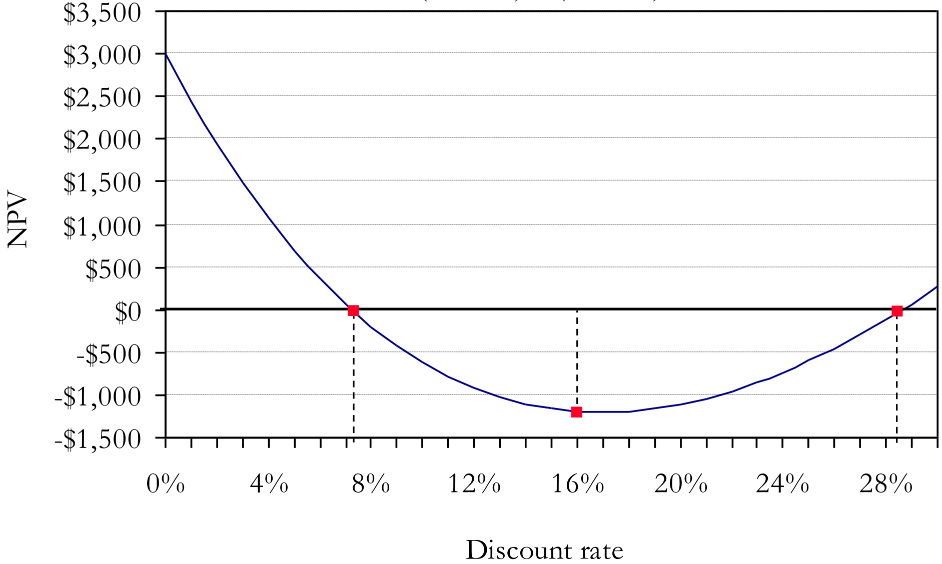
Year 0	*Year 1*	*Year 2*
\$145,000	–\$342,000	\$200,000

$$NPV = 0 = 145000 - \frac{342000}{(1+IRR)} + \frac{200000}{(1+IRR)^2}$$

- The two *IRR*s are the *same* as before…
  - 7.2% and 28.6%
- Decision now?

Problems with the IRR Method

$$NPV = 0 = 145000 - \frac{342000}{(1+IRR)} + \frac{200000}{(1+IRR)^2}$$



Decision now if the project's required rate of return is 16% (that is, lies between 7.2% and 28.6%)?

8.5 Comparing the IRR and NPV Methods

- *Independent projects* are projects where the decision to accept one project does not affect the decision to accept or reject other projects
  - Assumes that there are enough funds for *all* potential independent projects being considered
  - *Examples:* A development of two separate pieces of land, or expanding the Melbourne and London offices
- Decision rule for independent projects
  - Invest in *all* positive *NPV* projects

Comparing the IRR and NPV Methods

- *Mutually exclusive projects* are projects where the acceptance of one project *rules out* the acceptance of other (competing) projects
  - *Example:* A piece of land on which a factory is to be built, which rules out an alternate project of (say) building a warehouse on that land
- Decision rule for mutually exclusive projects
  - Assuming the projects being considered are worth undertaking (that is, they are positive *NPV* projects)…
  - Invest in the *highest* *NPV* project
- Does the *IRR* rule work the same way here?

Comparing the IRR and NPV Methods

- *Example:* Consider two one-year, mutually exclusive projects that have the following cash flows, *NPV*s and *IRR*s. Which project should the firm prefer?

	Project X	*Project Y*
I_0	–\$100,000	–\$500,000
C_1	\$150,000	\$625,000
NPV (at 10%)	\$36,364	\$68,182
IRR	50%	25%

- *Note the difference in the scale of investments between the two projects*
- *Decision?*

Comparing the IRR and NPV Methods

- *Example:* Consider two three-year projects with the following net cash flows. What decision would the firm make if the projects are mutually exclusive and the required rate of return is 17%? How does the decision change when the required rate of return is 10%?

Year	*Project A*	*Project B*
0	–$120,000	–$120,000
1	$100,000	$10,000
2	$50,000	$60,000
3	$15,000	$120,000

- *Note the difference in the timing of the cash flows between the two projects*

Comparing the IRR and NPV Methods

- The *NPV*s when the required rate of return is 17% are…

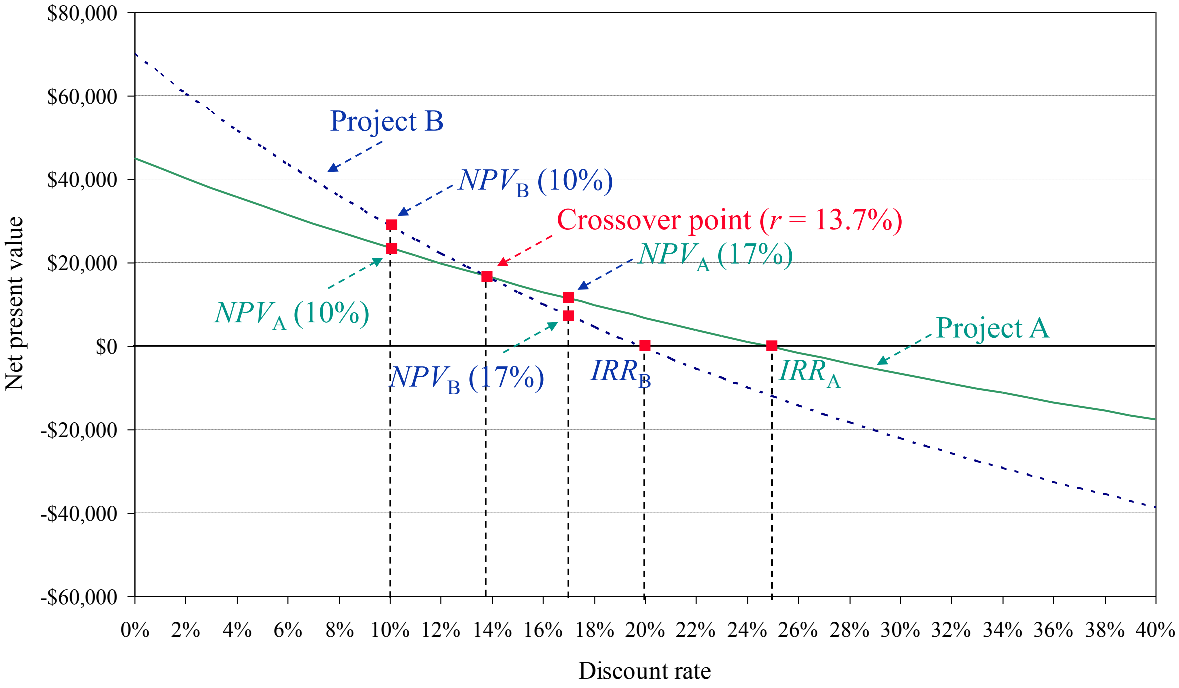
	Project A	*Project B*
NPV at 17%	$11,361	$7,302
IRR	24.8%	19.8%

- The *NPV*s when the required rate of return is 10% are…

	Project A	*Project B*
NPV at 10%	$23,501	$28,835
IRR	24.8%	19.8%

- *Decision?*

Comparing the IRR and NPV Methods



Comparing the IRR and NPV Methods

- For mutually exclusive projects, the *IRR* and *NPV* methods can be made consistent by considering the incremental "projects" A – B (*or* B – A)
- Look at the *difference* in net cash flows of the lower *IRR* project and the net cash flows of the higher *IRR* project

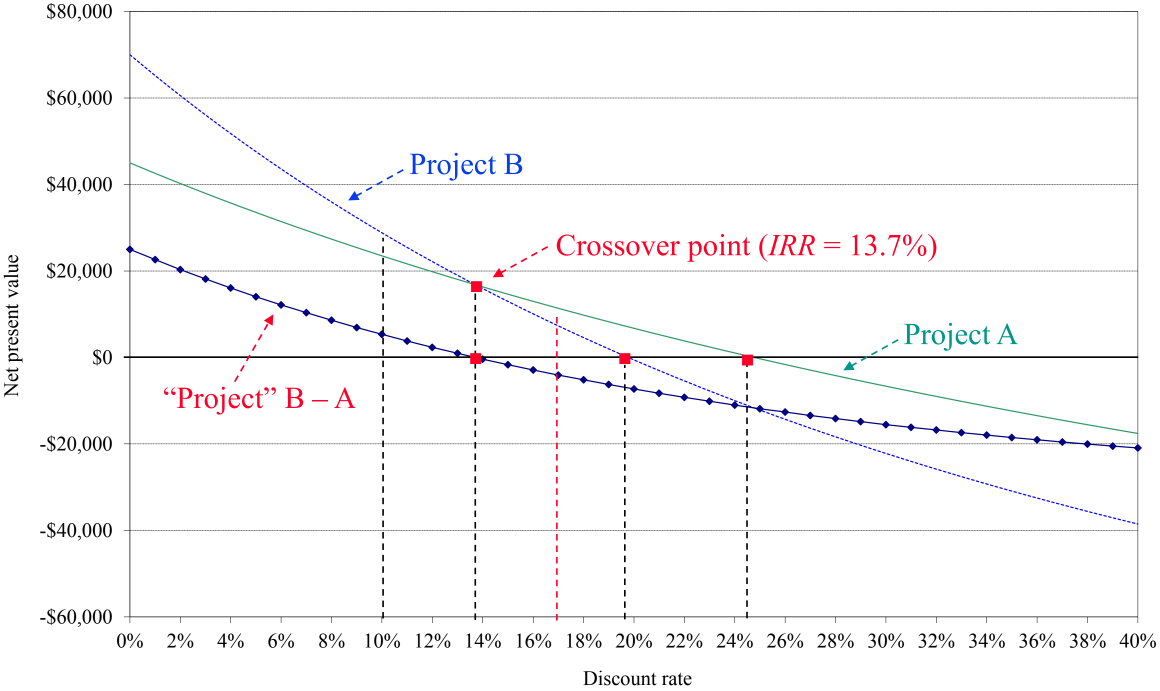
Year	*Project A*	*Project B*	*"Project" B – A*
0	–\$120,000	–\$120,000	\$0
1	\$100,000	\$10,000	–\$90,000
2	\$50,000	\$60,000	\$10,000
3	\$15,000	\$120,000	\$105,000
NPV (10%)	\$23,501	\$28,835	–
IRR	24.8%	19.8%	13.7%

Comparing the IRR and NPV Methods

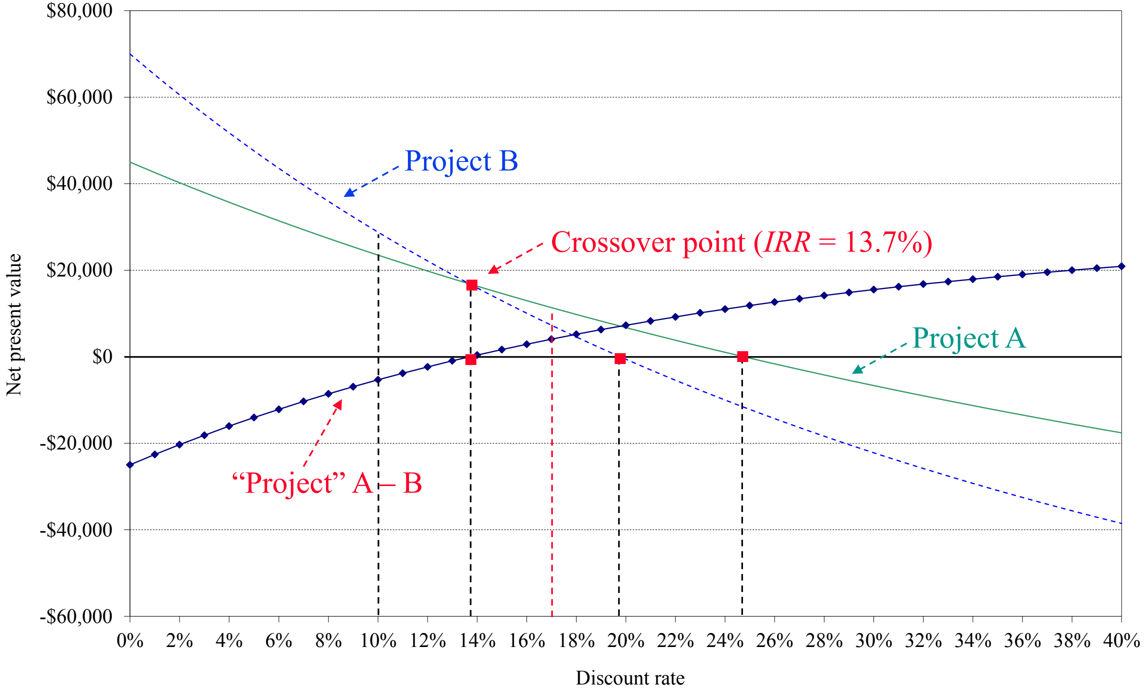
- Is it worth investing in the lower *IRR* project B *in preference to* the higher *IRR* project A?
- The *IRR* of the incremental "project" can be calculated using…
- $NPV_{B\text{-}A} = 0 = -90000/(1 + IRR_{B\text{-}A})^1 + 10000/(1 + IRR_{B\text{-}A})^2 + 105000/(1 + IRR_{B\text{-}A})^3$
- $IRR_{B\text{-}A} = 13.7\% > 10.0\%$

- What if we'd calculated $IRR_{A\text{-}B}$ (where $NPV_{A\text{-}B} = 0$) instead?
- Which method is preferable here – *NPV* or incremental *IRR*?

Comparing the IRR and NPV Methods



Comparing the IRR and NPV Methods



Problems with the Incremental IRR

- The incremental *IRR* may not exist
- Multiple incremental *IRRs* can exist
- The fact that the *IRR* exceeds the required rate of return for both projects does not necessarily imply that either project has a positive *NPV*
- The individual projects may have different required rates of return
  - Not clear which required rate of return should be used to compare with the incremental *IRR*

8.6 Analyzing Projects with Resource Constraints

- A *caveat* to the decision rule for independent projects exists if there is a *binding resource constraint*, such as…
  - Limits on total capital budget
  - Limits on production capacity
  - Limits on managerial time
- For such projects we can use an additional metric, the profitability index (*PI*)
  - $PI = NPV/I_0$
  - *Note:* If needed, substitute the specific resource item for I_0
- *Decision:* Rank projects according to the profitability index and accept projects with the highest *PI*s first until the capital budget is exhausted

Analyzing Projects with Resource Constraints

- *Example:* The following independent projects are being considered by a firm which has a total capital budget of $100,000. Which projects should the firm accept? How would your analysis change if the capital budget was $80,000?

Project	*Initial Outlay*	*NPV*
A	$40,000	$100,000
B	$30,000	$90,000
C	$30,000	$80,000
D	$20,000	$45,000

- Note that if there were *no* capital budget all projects would be acceptable as they are all positive *NPV* projects

Analyzing Projects with Resource Constraints

- The projects ranked according to their profitability index ($PI = NPV/I_0$) result in the following ranking

Project	*Initial Outlay*	*NPV*	*PI*
B	$30,000	$90,000	3.00
C	$30,000	$80,000	2.67
A	$40,000	$100,000	2.50
D	$20,000	$45,000	2.25

- Decision when the capital budget is $100,000?
- Decision when the capital budget is $80,000?

Analyzing Projects with Resource Constraints

- The main limitations of the profitability index are…
  - The projects being undertaken using the profitability index approach *must* fully exhaust the available (constrained) resource
  - There must be only *one* relevant resource constraint that is relevant to the analysis
    - *Example:* The method will not work if there is a capital budget *and* a production capacity constraint

8.7 Payback Period

- A project's payback period is the time it takes for the initial cash outlay on a project to be recovered from the net (after-tax) cash flows
  - The discounted payback period does the same thing but uses *discounted* cash flows
- *Decision rules*
  - A project is acceptable if its payback period is less than a prespecified maximum payback period
  - For mutually exclusive projects, the project with the shortest payback period is preferred (assuming they all meet the maximum payback period threshold)

Payback Period

- *Example:* A firm is considering three mutually exclusive projects that require an initial outlay of $100,000 and that generate the following pattern of cash flows. The firm typically accepts projects with a payback period less than 2 years

Project	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Payback*
C	$100,000	--	--	$10,000	1.0 year
D	$50,000	$50,000	$50,000	$50,000	2.0 years
E	$50,000	$30,000	$30,000	$90,000	2.7 years

- *Note:* Payback for project E = 2 + 20/30 = 2.7 years
- Decision?

Problems with Payback Period

- The payback period method fails to take account of the cash flows that occur after the payback period cutoff date
- It is biased against projects that have longer development periods
  - *Examples:* Mining and exploration projects
- It ignores the time value of money
- What about the *discounted* payback period method?

- Is there any use for the payback period method?
- What method(s) should a company use?

Key Concepts

- The *NPV* method is recommended for investment evaluation as it is consistent with the maximization of shareholder wealth
- *NPV* is simple to use and gives rise to fewer problems than the *IRR* method
- The *IRR* method has severe drawbacks including multiple *IRR*s as well as undefined *IRR*s
- The *NPV* and *IRR* methods can be made consistent with each using the incremental *IRR* approach
- The profitability index is the appropriate method to evaluate independent projects in the presence of a resource constraint
- Other evaluation methods such as the payback period can be used in conjunction with the *NPV*, but with care

Formula Sheet

- Net present value: $NPV = \sum_{t=1}^{N} \frac{C_t}{(1+r)^t} - I_0$
- Internal rate of return: $NPV = 0 = \sum_{t=1}^{N} \frac{C_t}{(1+IRR)^t} - I_0$
- Profitability index: $PI = NPV/I_0$

(*Note:* The formula sheets on the mid semester and final exams will contain all the formulas covered in lectures but *without* the descriptions)