Evaluating projects (3)

Class 5
Financial Management, 15.414

Today

Evaluating projects

- Real options
- Alternative investment criteria

Reading

- Brealey and Myers, Chapters 5, 10, and 11

Evaluating projects

DCF analysis

$$NPV = CF_0 + \frac{CF_1}{(1+r)} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \frac{CF_4}{(1+r)^4} + \frac{CF_5}{(1+r)^5} + \ldots$$

Forecast cashflows
Opportunity costs, inflation, working capital, taxes, depreciation

Discount at the opportunity cost of capital
Rate of return required by investors for projects with similar risk

- **Static-thinking trap**
  Decision is made today, then plan is followed

- **Real options**
  Recognize that decisions can be revised

Example

Southern Company is evaluating its alternatives for complying with the Clean Air Act. It can: (1) continue to burn HS coal and buy allowances; (2) install scrubbers and sell allowances; (3) switch to LS coal. Phase I of the Clean Air Act takes effect in 1995 and Phase II begins in 2000.

Evaluating projects

Real options

- Option to expand / make follow-up investments
- Option to abandon unprofitable projects
- Option to wait before investing
- Option to change production methods

Key elements

- Information will arrive in the future
- Decisions can be made after receiving this information

Example 1

Your firm has just developed a new handheld PDA, code-named the Model A.

- To produce Model A, the firm would need to invest $20 million in new plant and equipment.
- The firm would sell Model A for a per unit profit of $200. Sales are expected to be 30,000 in year 1, 40,000 in year 2, and 50,000 in year 3.
- Net working capital and taxes are zero, and r = 12%.
- Model B will replace Model A in year 4, with the same price and unit costs. Sales are forecasted to be 60,000 in year 4, 80,000 in year 5, and 100,000 in year 6. Model B would require $30 million in new plant and equipment.

PDA, cont.

Should your firm proceed with the Model A?

Model A

- $$\text{NPV} = -20{,}000 + \frac{30 \times 200}{1.12} + \frac{40 \times 200}{1.12^2} + \frac{50 \times 200}{1.12^3} = -\$1{,}148$$

Model B

- $$\text{NPV}_{\text{yr 3}} = -30{,}000 + \frac{60 \times 200}{1.12} + \frac{80 \times 200}{1.12^2} + \frac{100 \times 200}{1.12^3} = \$7{,}705$$

- $\text{NPV}_{\text{Today}} = 7{,}705 / 1.12^3 = \$5{,}484$

- Combined NPV = –1,148 + $5,484 = **$4,336** ⇒ **Proceed.**

PDA, cont.

What if Model B requires an investment of $40 million?

Model A

- $NPV = -20{,}000 + \frac{30 \times 200}{1.12} + \frac{40 \times 200}{1.12^2} + \frac{50 \times 200}{1.12^3} = -\$1{,}148$

Model B

- $NPV_{yr\ 3} = -40{,}000 + \frac{60 \times 200}{1.12} + \frac{80 \times 200}{1.12^2} + \frac{100 \times 200}{1.12^3} = -\$2{,}295$
- $NPV_{Today} = -2{,}295 / 1.12^3 = -\$1{,}634$
- Combined NPV = –1,148 – $1,634 = **–$2,782** ⇒ **Reject?**

PDA, cont.

What's missing?

Information will arrive about Model B's sales or costs before a decision has to be made.

Sales …

In year 3, sales for Model A are expected to be 50,000. But they might be either 25,000 or 75,000.

If sales are 25,000 in year 3
Forecast for Model B is 30,000, 40,000, 50,000

If sales are 75,000 in year 3
Forecast for Model B is 90,000, 120,000, 150,000

PDA, cont.

Model B decision

- **If sales in year 3 are 25,000**

$$NPV_{yr\,3} = -40{,}000 + \frac{30 \times 200}{1.12} + \frac{40 \times 200}{1.12^2} + \frac{50 \times 200}{1.12^3} = -\$21{,}148$$

- **If sales in year 3 are 75,000**

$$NPV_{yr\,3} = -40{,}000 + \frac{90 \times 200}{1.12} + \frac{120 \times 200}{1.12^2} + \frac{150 \times 200}{1.12^3} = \$16{,}556$$

- **Continue only if year 3 sales are good**

$$\text{Expected } NPV_{yr\,3} = \underbrace{.5 \times 0}_{\text{Abandonment option}} + .5 \times 16{,}556 = \$8{,}278$$

PDA, cont.

Should the firm proceed with the Model A?

- **Model A**

  NPV = –\$1,148

- **Model B**

  Expected $NPV_{yr\ 3}$ = \$8,278

  NPV_{Today} = \$8,278 / 1.12^3 = \$5,892

  Combined NPV = –1,148 + \$5,892 = **\$4,744** ⇒ **Proceed**.

Example 2

You have the opportunity to purchase a copper mine for $400,000. The mine contains 1 million kgs of copper for sure. If you buy the mine, you can extract the copper now or wait one year. Extraction takes one year and costs $2 / kg.

The current price of copper is $2.2 / kg. The price is expected to increase 5% for the next two years.

If the discount rate is 10%, should you buy the mine?

Copper mine, cont.

Copper prices

- The current price of copper is $2.2 / kg.
- The price is expected to increase 5% next year, but the actual change might be either a 20% drop or a 30% increase. After that, the price will increase by 5% for certain.

$P_1 = 2.86$

$P_0 = 2.2$ $\qquad$ $\text{Exp}[P_1] = .5\times 2.86 + .5\times 1.76 = \$2.31$

$P_1 = 1.76$

$\text{Exp}[P_2] = \$2.31 \times 1.05 = \$2.4255$

Copper mine, cont.

Static NPV

- **Extract immediately**

Costs = $2,000,000

Exp[Revenues] = 2.31 × 1 million = $2,310,000

NPV = –400,000 + (2,310,000 – 2,000,000) / 1.1 = –$118,182

- **Extract in one year**

Costs = $2,000,000

Exp[Revenues] = 2.4255 × 1 million = $2,425,500

NPV = –400,000 + (2,425,500 – 2,000,000) / 1.1^2 = –$48,347

Copper mine, cont.

Where's the real option?

We are not committed to extracting in one year. We can make the decision once we see copper prices.

Extraction costs = 2.0 / kg.

Copper prices
If P_1 = 2.86 $\Rightarrow$ $P_2 = 2.86 \times 1.05 = \$3.003$
If P_1 = 1.76 $\Rightarrow$ $P_2 = 1.76 \times 1.05 = \$1.848$

Decision
Extract only if $P_1 = \$2.86$
$CF_2 = (3.003 - 2.000) \times 1 \text{ million} = \$1{,}003{,}000$

Copper mine, cont.

Dynamic NPV

- **Extract in one year**

If $P_1 = 1.76 \Rightarrow NPV_{yr\ 1} = 0$

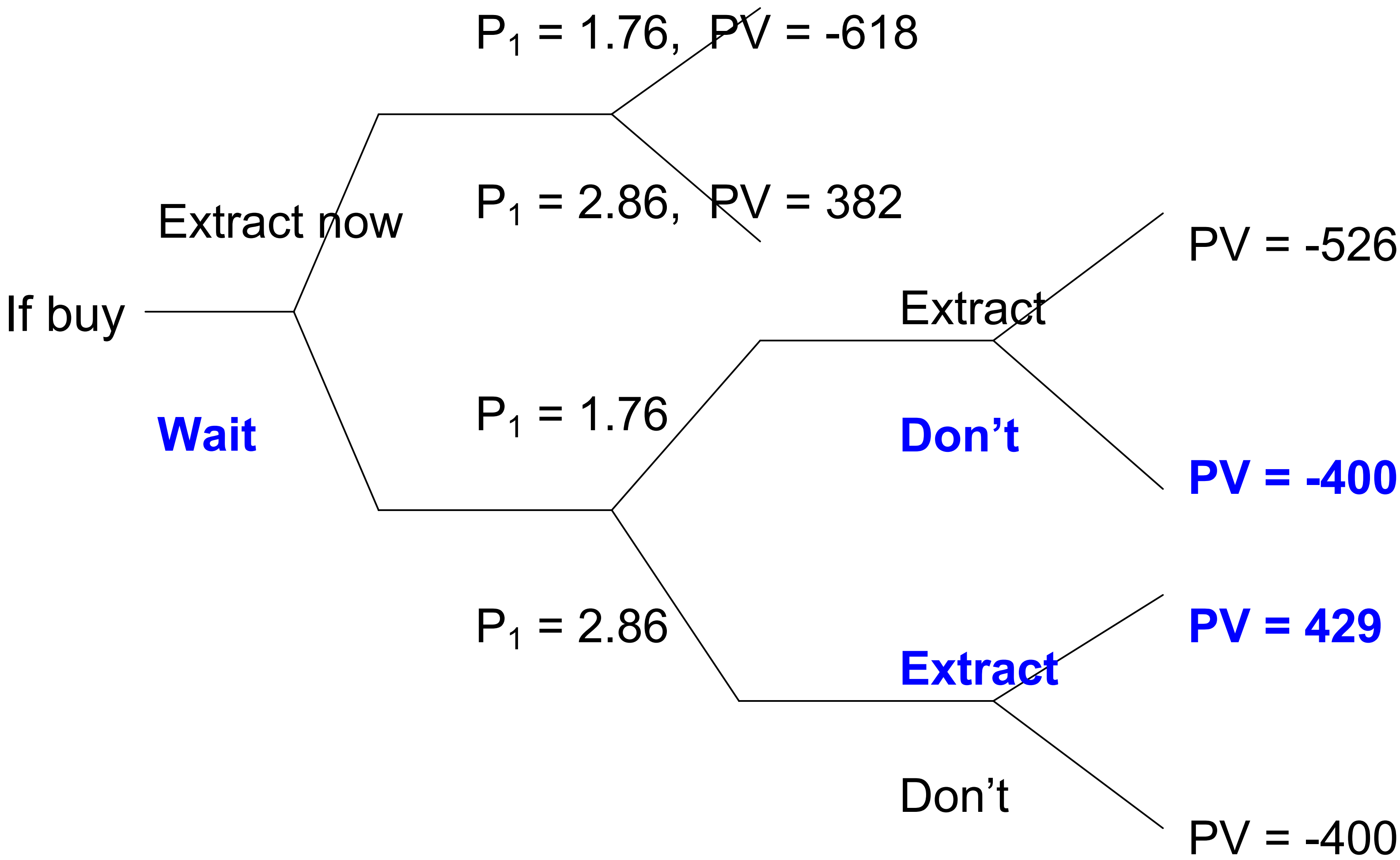
If $P_1 = 2.86 \Rightarrow NPV_{yr\ 1} = 1{,}003{,}000 / 1.1 = \$911{,}818$

Expected $NPV_{yr\ 1} = .5 \times 0 + .5 \times 911{,}818 = \$455{,}909$

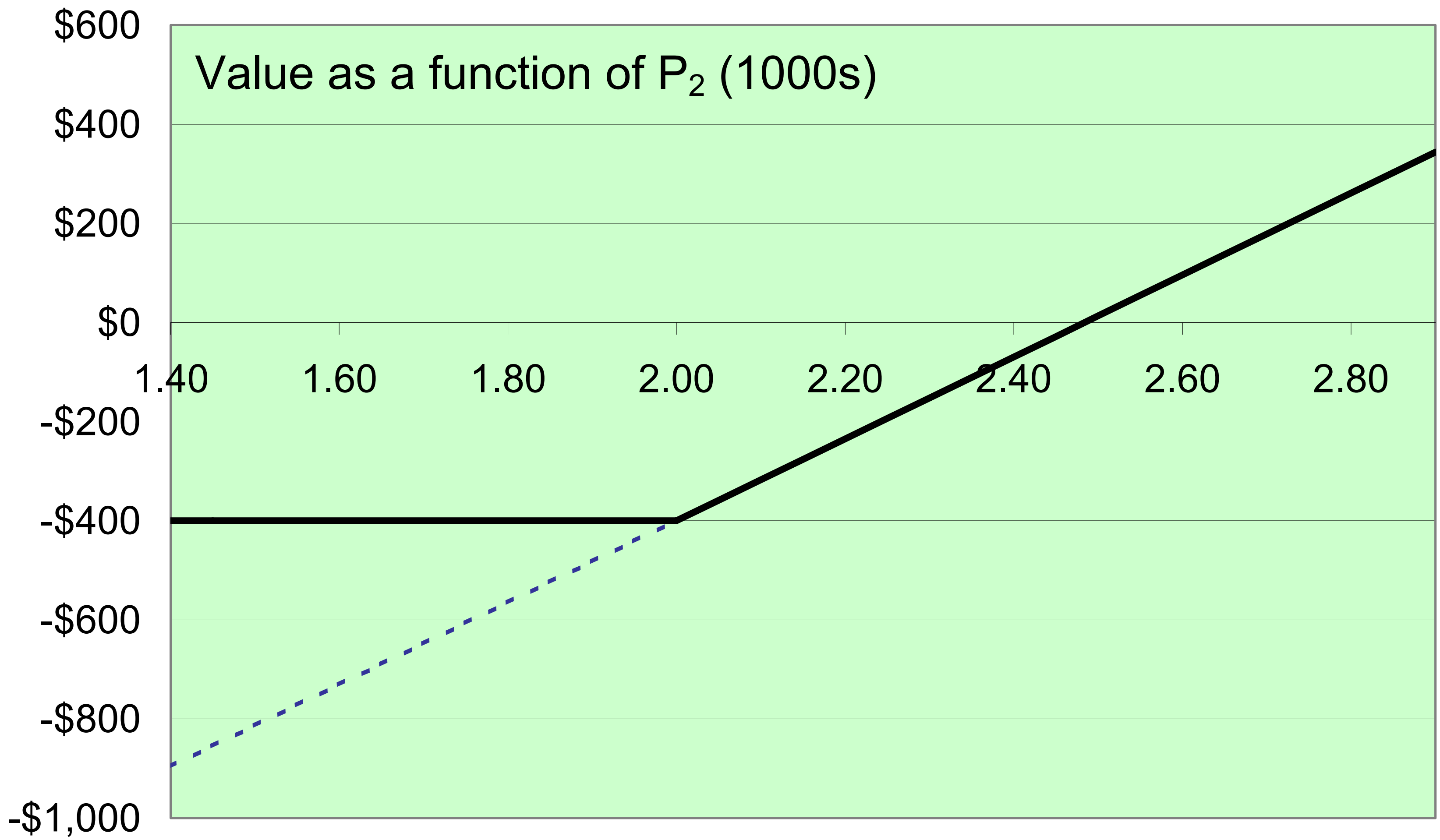
$\mathbf{NPV_{today} = -400{,}000 + 455{,}909 / 1.1 = \$14{,}463.}$

Copper mine, cont.

Decision tree



Copper mine, cont.



Copper mine, cont.

A caution

Should we use the same discount rate for years 1 and 2?

- **During extraction**
  In year 2, project risk is very low looking forward
  Profits of $1,003,000 for sure

- **Real option**
  In year 1, project risk is very high
  Project has value of either $0 or $911,818 at end of year

Rule: use a higher discount rate to value the option
But how high?
Black-Scholes option pricing formula

Copper mine, cont.

A note on volatility

Copper prices have become more volatile: They are still expected to increase 5% next year, but the actual change might be either a 40% drop or a 50% increase (compared with a change of –20% or 30% before).

How would this affect NPV?

If P_1 = 3.30 ⇒ $P_2 = 3.465$ ⇒ $CF_2 = \$1{,}465{,}000$
If P_1 = 1.32 ⇒ $P_2 = 1.382$ ⇒ $CF_2 = \$0$ (why?)

Expected $NPV_{yr\ 1} = .5 \times 0 + .5 \times (1{,}465{,}000 / 1.1) = \$665{,}909$

$NPV_{today} = -400{,}000 + 665{,}909 / 1.1 = \$205{,}372$

Example 3

Boeing is evaluating whether or not to proceed with development of a new regional jet. The firm expects development to take 2 years, cost roughly \$750 million, and it hopes to get unit costs down to \$36 million. Boeing forecasts that it can sell 30 planes each year at an average price of \$41 million.

Where are the real options?

Option to abandon project after 1st or 2nd year of R&D
Option to expand production
Option to shut down production if costs rise or prices fall

What's wrong with simple NPV?

$$NPV = -\frac{200}{1+r} - \frac{550}{(1+r)^2} + \frac{150}{(1+r)^3} + \frac{150}{(1+r)^4} + \frac{150}{(1+r)^5} + \ldots$$

Example 4

Microsoft has just developed the Xbox, and it must now decide whether to proceed with production. If it does, Microsoft would have to invest $700 million in new PP&E immediately. If the Xbox is successful, Microsoft will earn cash profits of $350 million annually. If the Xbox fails, it will lose $200 million annually. The outcomes are equally likely.

Where are the real options?

Real options

Summary

- **Options are pervasive**
  We often have the option to revise our decisions when new information arrives.

- **Options can have enormous value**
  Static NPV analysis that ignores imbedded options can lead to bad decisions.

- **NPV is still correct when applied correctly**

- **We don't need to get fancy**
  Formal option pricing models, like Black-Scholes, can sometimes be used. But the basic point is much simpler.

Investment criteria

Graham and Harvey (2000)

- Survey of CFOs finds that 75% of firms use NPV 'always' or 'almost always.'

Alternatives

- Payback period
- Accounting rates of return (ROA or ROI)
- Internal rate of return (IRR)

Investment criteria

Properties of NPV

- **Cashflows**
  NPV is based on cashflows and explicitly measures value. It is flexible enough to take into account strategic issues.

- **Timing and risk**
  NPV recognizes that cash received in the future is worth less than cash today, and that risky cashflows are worth less than safe cashflows.

- **Objective**
  NPV is objective. Take all projects with NPV > 0 because these create value.

Alternative 1

Payback period

How long it takes to recover the firm's original investment (or how long the project takes to pay for itself).

Example
Payback is 3 years for all of the following investments:

Project	CF_0	CF_1	CF_2	CF_3	CF_4
A	-100	20	30	50	60
B	-100	50	30	20	60
C	-100	50	30	20	600

Issues
Ignores cashflows after the payback period, crude timing adjustment, no risk adjustment

Alternative 2

Accounting rate of return

Defined in various ways. Accounting profits divided by some measure of investment.

ROA, ROE, ROI: return on assets, equity, or investment

Issues

- Ignores timing
- Accounting earnings ≠ cashflows
- Arbitrary changes in accounting can affect profitability
- Incentive distortions if used for compensation

Example

GM has just designed a new Saturn.

- Sales are expected to be 200,000 cars annually at a price of $18,000. Costs are expected to be $17,000 / car.

- GM expects to invest $400 million in working capital.

- GM must invest $400 million in new equipment and stamping machines. The equipment will be used for the full production cycle of the car, expected to be 4 years, and will have a salvage value of $60 million at the end.

- The tax rate is 40% and r = 10%.

Example, cont.

Book value of assets ($ million)

Year	0	1	2	3	4
Beg equip		400	315	230	145
Beg NWC		400	400	400	400
Beg assets		**800**	**715**	**630**	**545**
Depreciation		85	85	85	85
End equip	400	315	230	145	0
End NWC	400	400	400	400	0
End assets	**800**	**715**	**630**	**545**	**0**
Average BV	**400**	**758**	**673**	**588**	**273**

Average BV = (Beg BV + End BV) / 2

Example, cont.

Income and cashflows ($ million)

Year	0	1	2	3	4
Sales		3,600	3,600	3,600	3,600
COGS		3,400	3,400	3,400	3,400
Depreciation		85	85	85	85
EBIT		115	115	115	115
Taxes		46	46	46	46
Oper income		**69**	**69**	**69**	**69**
Cashflow	**-800**	**154**	**154**	**154**	**614**

Cashflow = Oper income + depr – ΔNWC + equipment

Example, cont.

ROA / ROI

Year	0	1	2	3	4
Oper income		69	69	69	69
Avg assets	400	758	673	588	273
ROA		**9.1%**	**10.3%**	**11.7%**	**25.3%**

- ROA_1 = average ROA = 14.1%
- ROA_2 = avg oper income / avg assets = 12.1%
- ROA_3 = avg oper income / initial investment = 8.6%

- **NPV ≈ $0**

Alternative 3

Internal rate of return

IRR is the discount rate that gives NPV = 0. Intuitively, IRR is the return on the project.

Accept projects with an IRR above the discount rate.

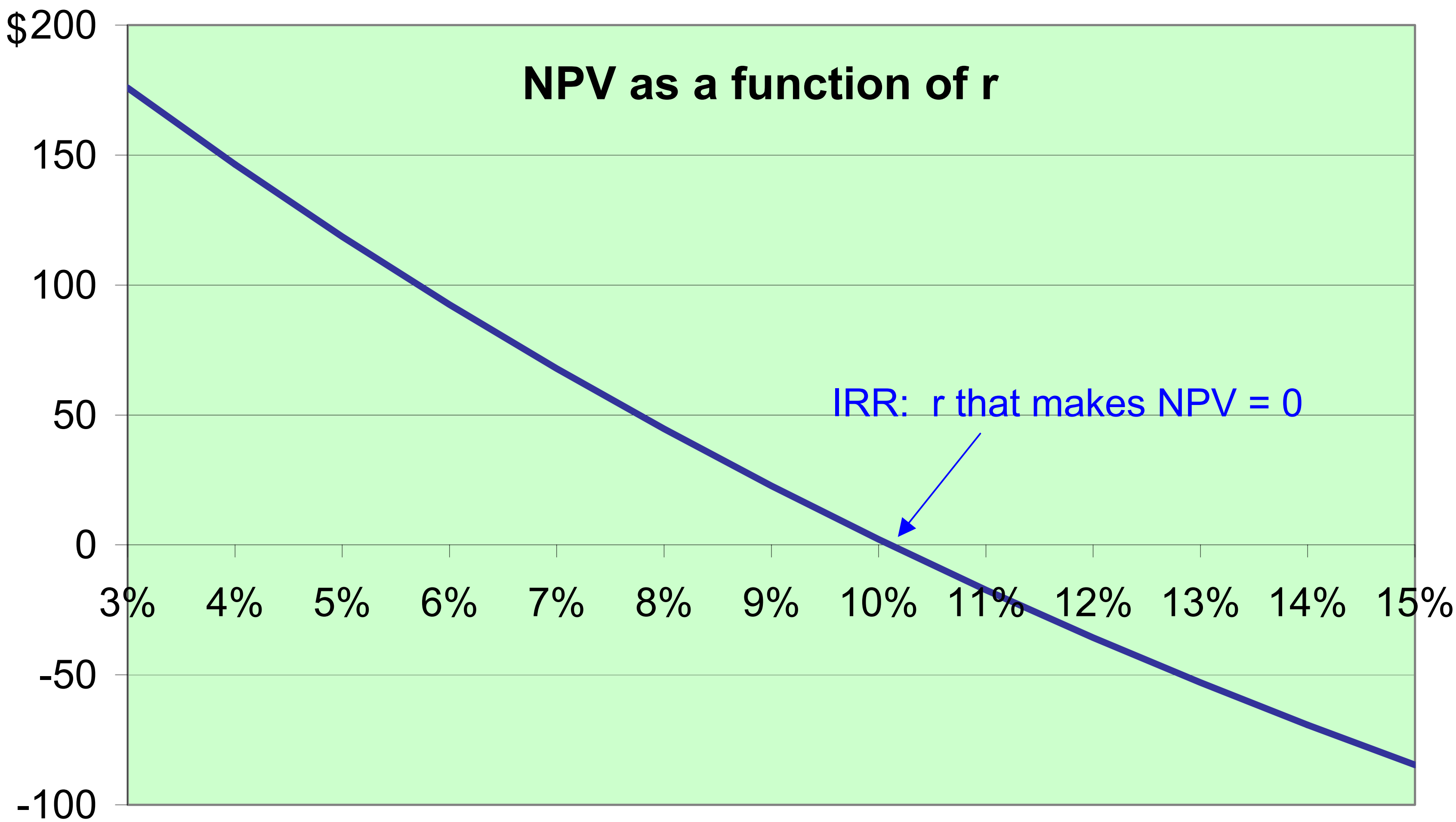
Example

Saturn cashflows

Year	0	1	2	3	4
Cashflow	-800	154	154	154	614

What is the IRR? 10.11%

IRR, cont.


NPV as a function of r
$200
150
100
50
0
-50
-100
3%
4%
5%
6%
7%
8%
9%
10%
11%
12%
13%
14%
15%
IRR: r that makes NPV = 0

IRR, cont.

IRR vs. NPV

Generally, if IRR is greater than the hurdle rate, then NPV is positive.

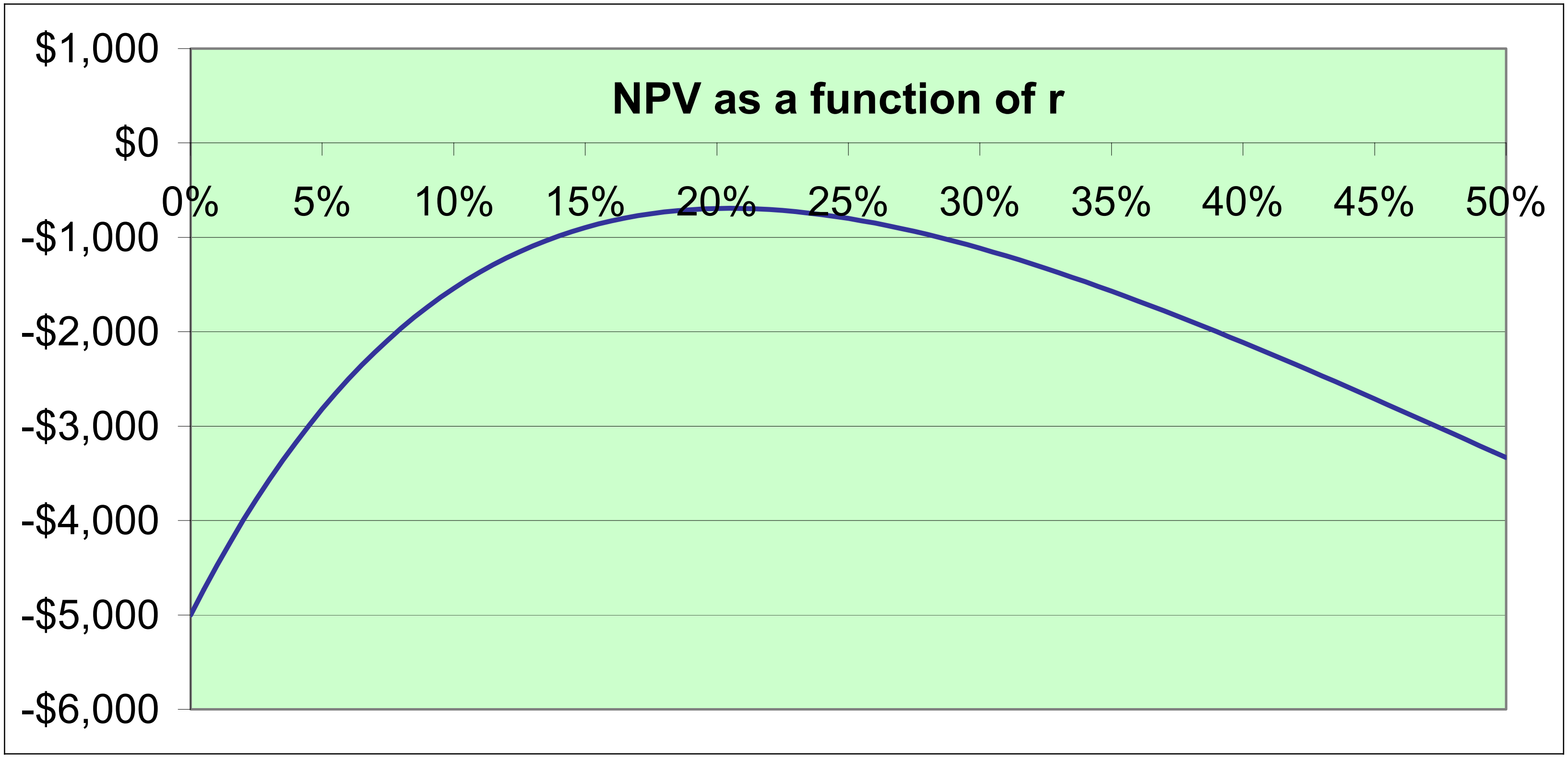
Issues

- Some projects have no IRR
- Multiple IRRs
- Lending or borrowing?
- Mutually exclusive investments

IRR, cont.

Problem 1: Some projects do not have an IRR

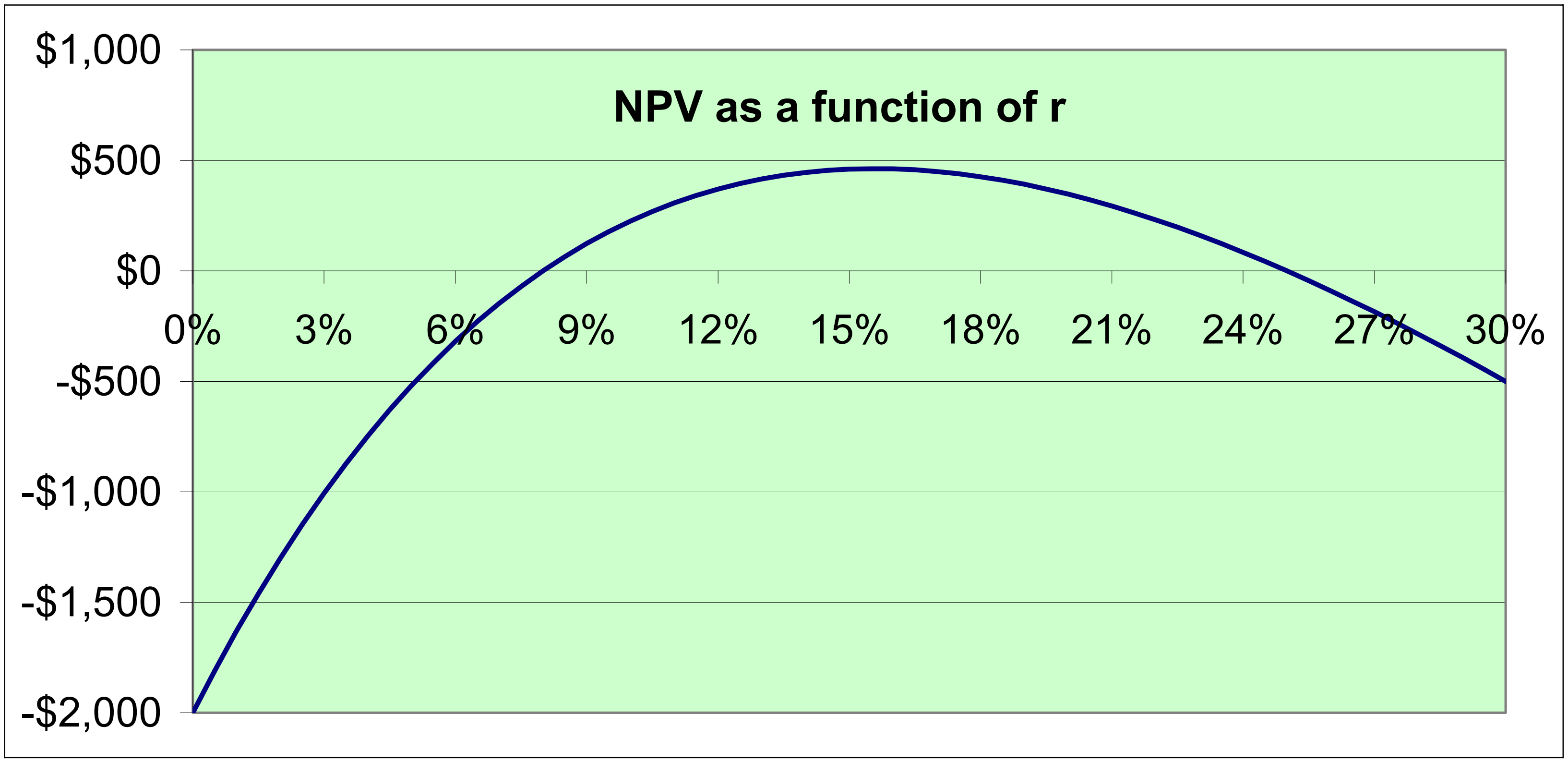
CF_0 = -105,000, CF_1 = 250,000, CF_2 = -150,000



IRR, cont.

Problem 2: Some projects have multiple IRRs

CF_0 = -100,000, CF_1 = 233,000, CF_2 = -135,000

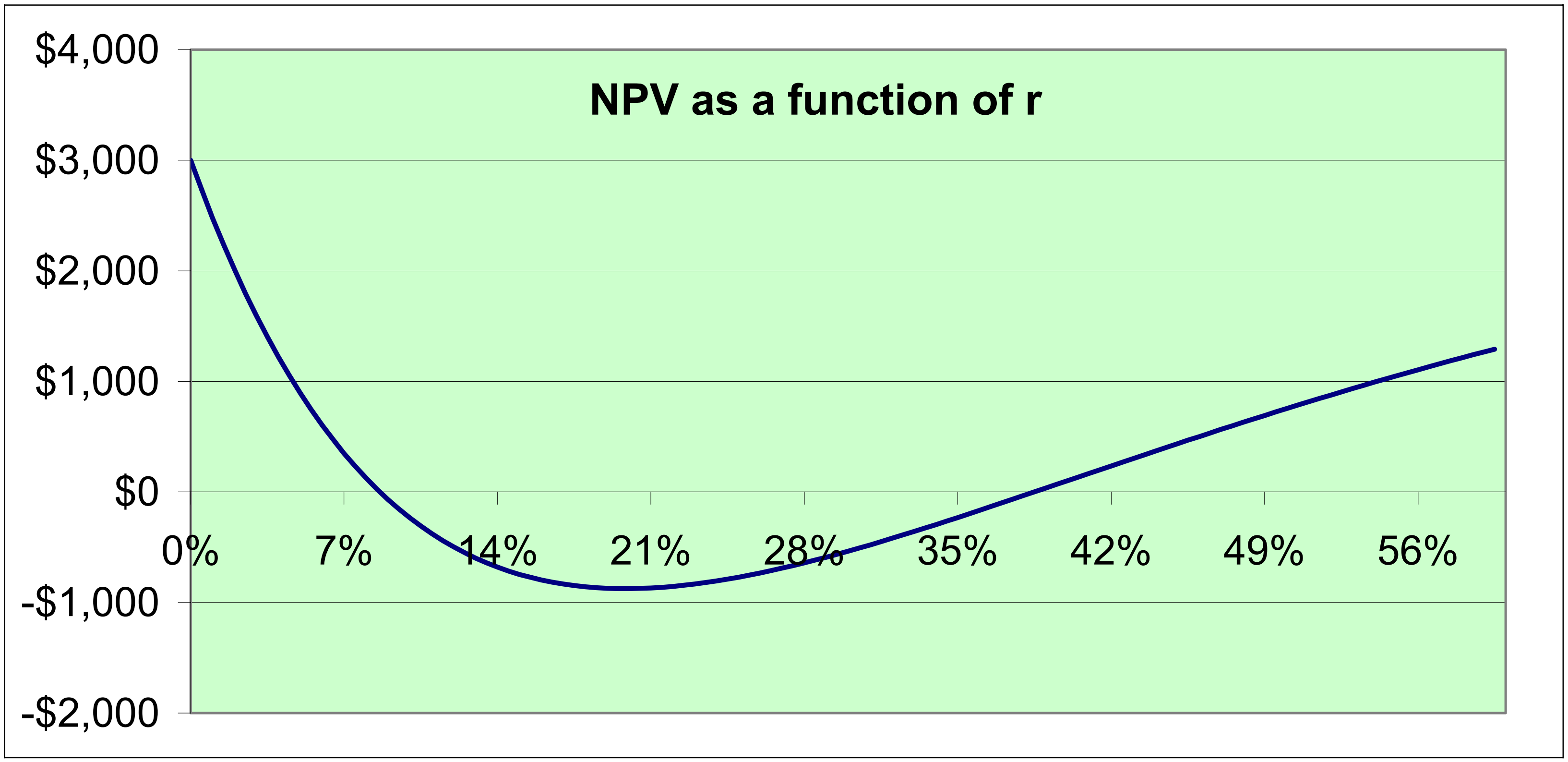


IRR, cont.

Example 2

CF_0 = -20,100, CF_1 = 160,000, CF_2 = -302,900, CF_3 = 166,000

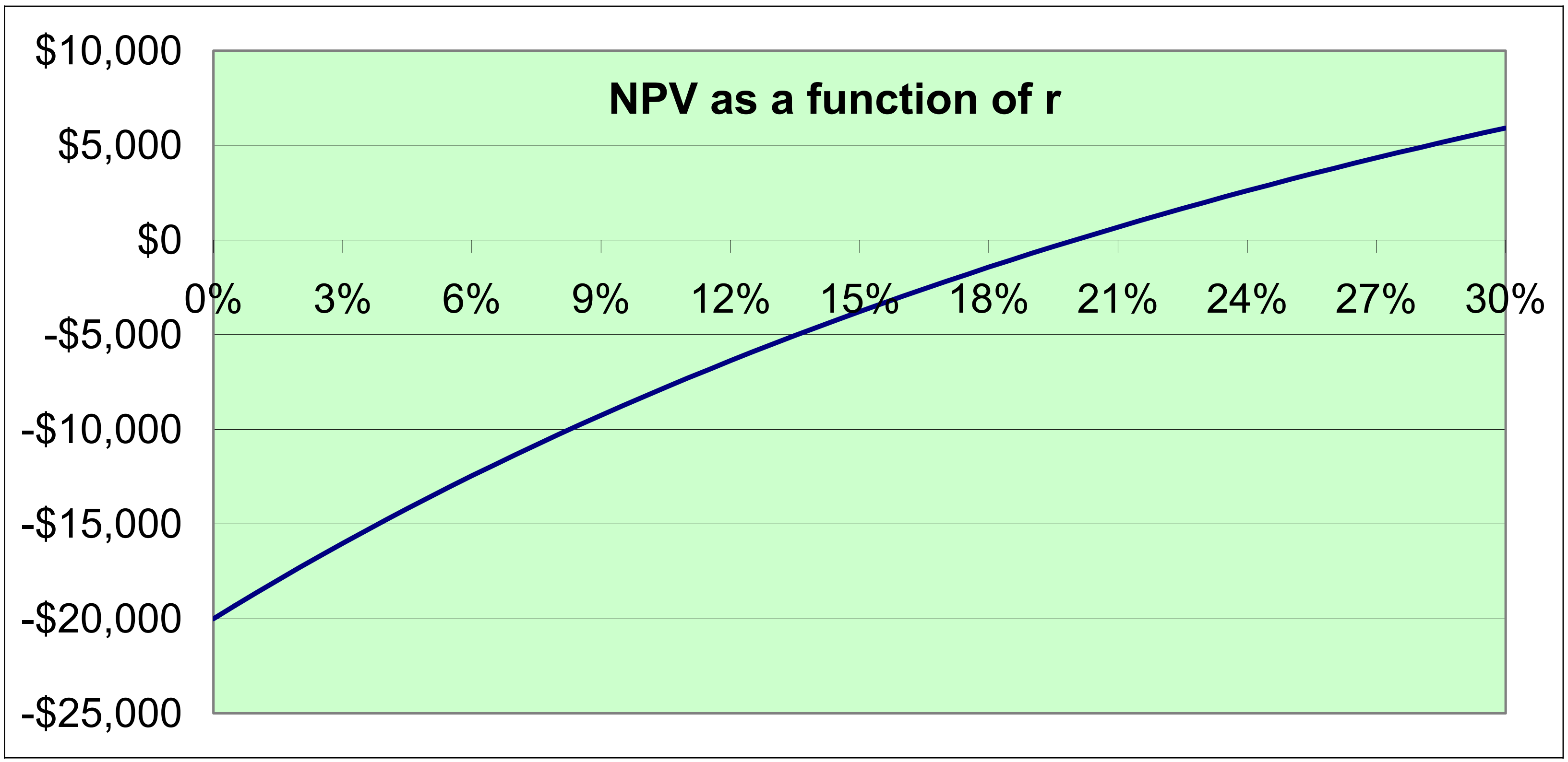
Three IRRs: r = 8.6%, 38.5%, and 449%



IRR, cont.

Problem 3: The IRR rule must be reversed for a project with an initial cash inflow, $CF_0 > 0$.

$CF_0 = 100{,}000$, $CF_1 = -120{,}000$



IRR, cont.

Problem 4: Mutually exclusive projects
To choose among mutually exclusive projects, do not compare the IRRs. The project with the higher IRR does NOT have to have the higher NPV.

Two reasons not to use IRR

- **If the scale of the projects is different**
  Project A: $CF_0 = -1$, $CF_1 = 2$
  Project B: $CF_0 = -10$, $CF_1 = 15$

- **If the timing of the cashflows is different**
  Example on next page

IRR, cont.

If you can invest in only one of the following projects, which would you choose?

- **Project A**

  CF_0 = -10,000 CF_1 = 10,000 CF_2 = 1,000 CF_3 = 1,000

  IRR = 16.0%

- **Project B**

  CF_0 = -10,000 CF_1 = 1,000 CF_2 = 1,000 CF_3 = 12,000

  IRR = 13.4%

IRR, cont.