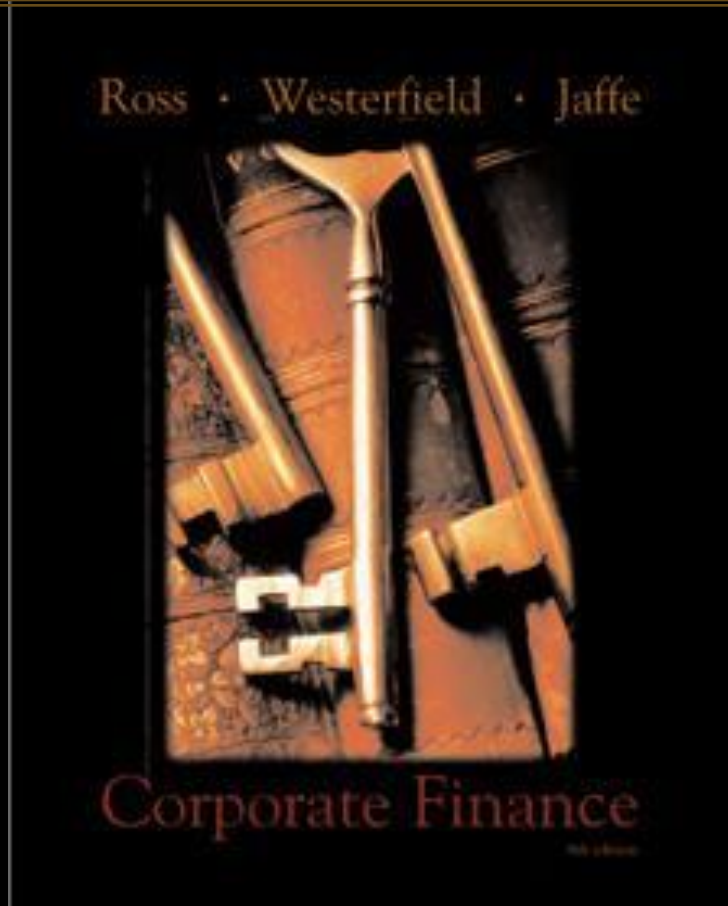


# Strategy and Analysis in Using Net Present Value

# 8

*Seventh Edition*



# Chapter Outline

---

8.1 Decision Trees

8.2 Sensitivity Analysis, Scenario Analysis, and  
Break-Even Analysis

8.3 Monte Carlo Simulation

8.4 Options

8.5 Summary and Conclusions

# 8.1 Decision Trees

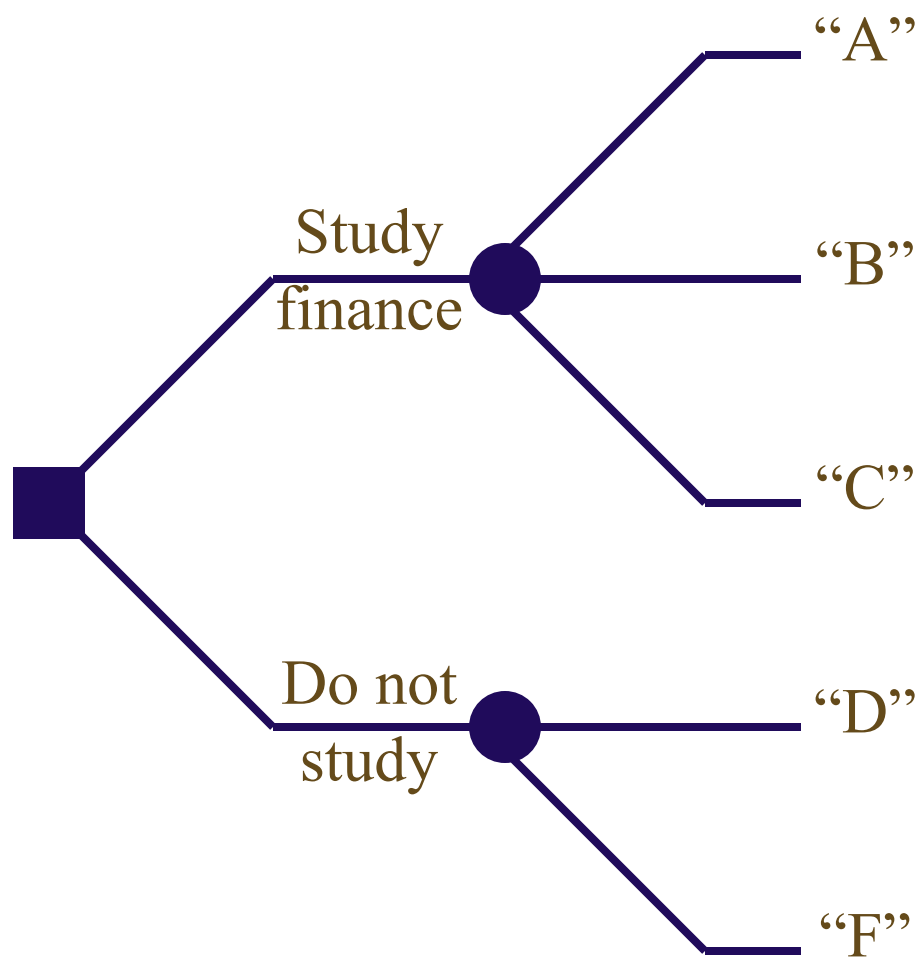
---

- Allow us to graphically represent the alternatives available to us in each period and the likely consequences of our actions.
- This graphical representation helps to identify the best course of action.

# Example of Decision Tree

---

Squares represent decisions to be made.



Circles represent receipt of information e.g. a test score.

The lines leading away from the squares represent the alternatives.

# Stewart Pharmaceuticals

---

- The Stewart Pharmaceuticals Corporation is considering investing in developing a drug that cures the common cold.
- A corporate planning group, including representatives from production, marketing, and engineering, has recommended that the firm go ahead with the test and development phase.
- This preliminary phase will last one year and cost \$1 billion. Furthermore, the group believes that there is a 60% chance that tests will prove successful.
- If the initial tests are *successful*, Stewart Pharmaceuticals can go ahead with full-scale production. This investment phase will cost \$1.6 billion. Production will occur over the next 4 years.

# Stewart Pharmaceuticals NPV of Full-Scale Production following Successful Test

Investment	Year 1	Years 2-5
Revenues		\$7,000
Variable Costs		(3,000)
Fixed Costs		(1,800)
Depreciation		(400)
Pretax profit		\$1,800
Tax (34%)		(612)
Net Profit		\$1,188
Cash Flow	-\$1,600	\$1,588

$$NPV = -\$1,600 + \sum_{t=1}^4 \frac{\$1,588}{(1.10)^t} = \$3,433.75$$

Note that the *NPV* is calculated as of date 1, the date at which the investment of \$1,600 million is made. Later we bring this number back to date 0.

# Stewart Pharmaceuticals NPV of Full-Scale Production following Unsuccessful Test

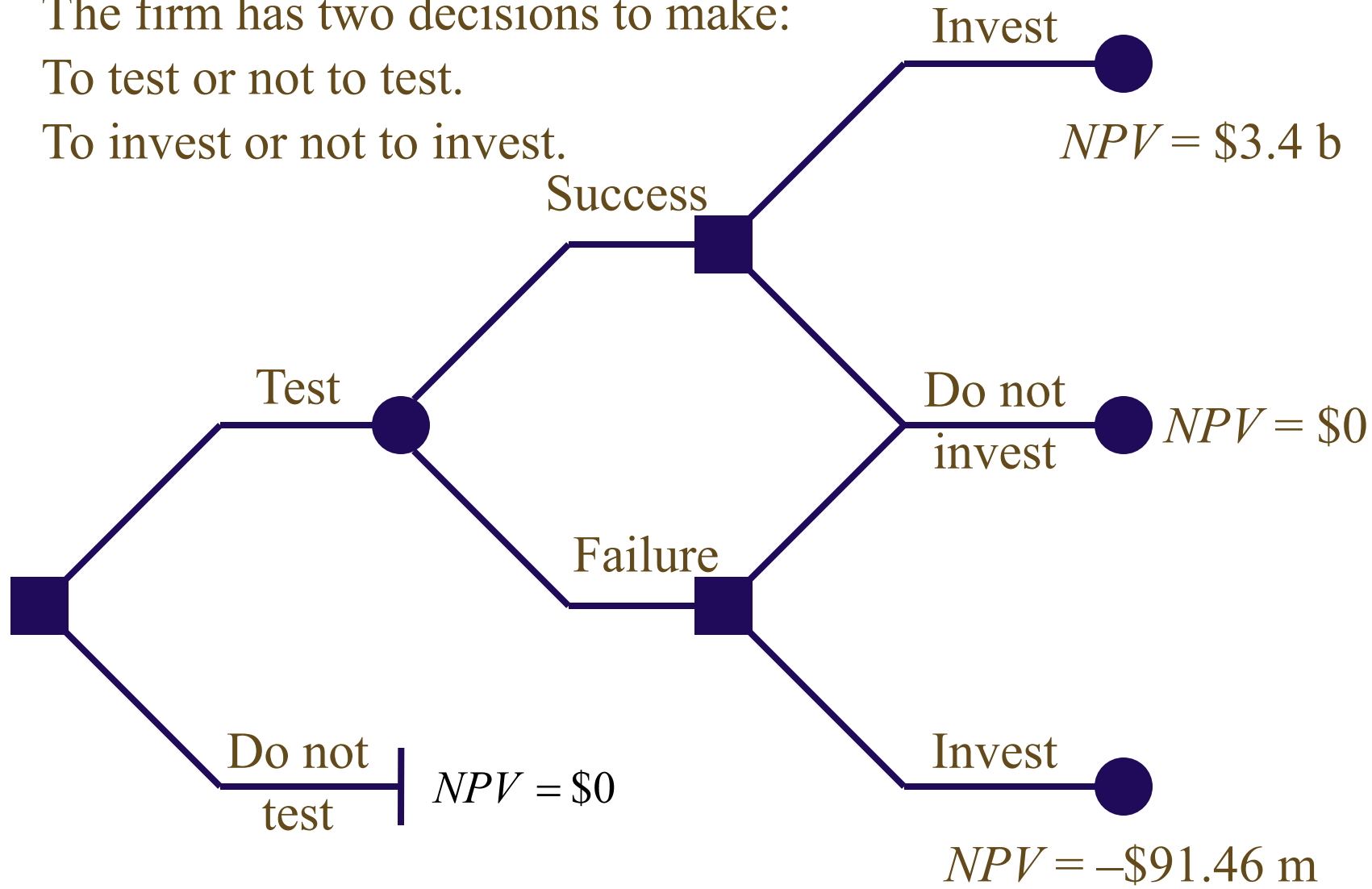
Investment	Year 1	Years 2-5
Revenues		\$4,050
Variable Costs		(1,735)
Fixed Costs		(1,800)
Depreciation		(400)
Pretax profit		\$115
Tax (34%)		(39.10)
Net Profit		\$75.90
Cash Flow	-\$1,600	\$475

$$NPV = -\$1,600 + \sum_{t=1}^4 \frac{\$475.90}{(1.10)^t} = -\$91.461$$

Note that the *NPV* is calculated as of date 1, the date at which the investment of \$1,600 million is made. Later we bring this number back to date 0.

# Decision Tree for Stewart Pharmaceutical

The firm has two decisions to make:  
To test or not to test.  
To invest or not to invest.





# Stewart Pharmaceutical: Decision to Test

---

- Let's move back to the first stage, where the decision boils down to the simple question: should we invest?
- The expected payoff evaluated at date 1 is:

$$\text{Expected payoff} = \left( \text{Prob. success} \times \text{Payoff given success} \right) + \left( \text{Prob. failure} \times \text{Payoff given failure} \right)$$

$$\text{Expected payoff} = (.60 \times \$3,433.75) + (.40 \times \$0) = \$2,060.25$$

- The NPV evaluated at date 0 is:

$$NPV = -\$1,000 + \frac{\$2,060.25}{1.10} = \$872.95$$

So we should test.

## 8.3 Sensitivity Analysis, Scenario Analysis, and Break-Even Analysis

---

- Allows us to look the behind the NPV number to see firm our estimates are.
- When working with spreadsheets, try to build your model so that you can just adjust variables in one cell and have the NPV calculations key to that.

# Sensitivity Analysis: Stewart Pharmaceuticals

---

- We can see that NPV is very sensitive to changes in revenues. In the Stewart Pharmaceuticals example, a 14% drop in revenue leads to a 61% drop in NPV

$$\% \Delta \text{Rev} = \frac{\$6,000 - \$7,000}{\$7,000} = -14.29\%$$

$$\% \Delta \text{NPV} = \frac{\$1,341.64 - \$3,433.75}{\$3,433.75} = -60.93\%$$

- For every 1% drop in revenue we can expect roughly a 4.25% drop in NPV

$$4.25 = \frac{-60.93\%}{14.29\%}$$

# Scenario Analysis: Stewart Pharmaceuticals

---

- A variation on sensitivity analysis is scenario analysis.
- For example, the following three scenarios could apply to Stewart Pharmaceuticals:
  1. The next years each have heavy cold seasons, and sales exceed expectations, but labor costs skyrocket.
  2. The next years are normal and sales meet expectations.
  3. The next years each have lighter than normal cold seasons, so sales fail to meet expectations.
- Other scenarios could apply to FDA approval for their drug.
- For each scenario, calculate the NPV.

# Break-Even Analysis: Stewart Pharmaceuticals

---

- Another way to examine variability in our forecasts is break-even analysis.
- In the Stewart Pharmaceuticals example, we could be concerned with break-even revenue, break-even sales volume or break-even price.
- To find either, we start with the break-even operating cash flow.

# Break-Even Analysis: Stewart Pharmaceuticals

---

- The project requires an investment of \$1,600.
 

N	4
---	---
- In order to cover our cost of capital (break even) the project needs to throw off a cash flow of \$504.75 each year for four years.
 

I/Y	10
-----	----
- This is the projects break-even operating cash flow,  $OCF_{BE}$ 

PV	1,600
----	-------

PMT	– 504.75
-----	----------

FV	0
----	---

# Break-Even Revenue Stewart Pharmaceuticals

Work backwards from  $OCF_{BE}$  to Break-Even Revenue

Revenue			\$5,358.72
Variable cost			\$3,000
Fixed cost			\$1,800
Depreciation			<u>\$400</u>
EBIT			\$158.72
Tax (34%)	$\frac{\$104.75}{0.66}$		<u>\$53.97</u>
Net Income			\$104.75
	$OCF = \$104.75 + \$400$		\$504.75

# Break-Even Analysis: $P_{BE}$

---

- Now that we have break-even revenue as \$5,358.72 million we can calculate break-even price.
- The original plan was to generate revenues of \$7 billion by selling the cold cure at \$10 per dose and selling 700 million doses per year,
- We can reach break-even revenue with a price of only:

$$\$5,358.72 \text{ million} = 700 \text{ million} \times P_{BE}$$

$$P_{BE} = \frac{\$5,378.72}{700 \text{ m}} = \$7.65 / \text{dose}$$



# Break-Even Analysis: Dorm Beds

---

- Recall the “Dorm beds” example from the previous chapter.
- We could be concerned with break-even revenue, break-even sales volume or break-even price.

# Dorm Beds Example

---

Consider a project to supply the University of Missouri with 10,000 dormitory beds annually for each of the next 3 years.

Your firm has half of the woodworking equipment to get the project started; it was bought years ago for \$200,000: is fully depreciated and has a market value of \$60,000. The remaining \$100,000 worth of equipment will have to be purchased.

The engineering department estimates you will need an initial net working capital investment of \$10,000.

# Dorm Beds Example

---

The project will last for 3 years. Annual fixed costs will be \$25,000 and variable costs should be \$90 per bed.

The initial fixed investment will be depreciated straight line to zero over 3 years. It also estimates a (pre-tax) salvage value of \$10,000 (for all of the equipment).

The marketing department estimates that the selling price will be \$200 per bed.

You require an 8% return and face a marginal tax rate of 34%.

# Dorm Beds $OCF_0$

---

What is the OCF in year zero for this project?

Cost of New Equipment      \$100,000

Net Working Capital Investment   \$10,000

Opportunity Cost of Old Equipment   \$39,600 = \$60,000 × (1-.34)

**\$149,600**

# Dorm Beds $OCF_{1,2}$

---

What is the  $OCF$  in years 1 and 2 for this project?

Revenue	$10,000 \times \$200 =$	\$2,000,000
Variable cost	$10,000 \times \$90 =$	\$900,000
Fixed cost		\$25,000
Depreciation	$100,000 \div 3 =$	<u>\$33,333</u>
EBIT		\$1,041,666.67
Tax (34%)		<u>\$354,166.67</u>
Net Income		\$687,500
	$OCF = \$687,500 + \$33,333$	<b>\$720,833.33</b>

# Dorm Beds $OCF_3$

---

Revenue	$10,000 \times \$200 =$	\$2,000,000
Variable cost	$10,000 \times \$90 =$	\$900,000
Fixed cost		\$25,000
Depreciation	$100,000 \div 3 =$	<u>\$33,333</u>
EBIT		\$1,041,666.67
Tax (34%)		<u>\$354,166.67</u>
Net Income		\$687,500
	$OCF = \$687,500 + \$33,333$	<b>\$720,833.33</b>

We get our \$10,000 NWC back and sell the equipment.

The after-tax salvage value is  $\$6,600 = \$10,000 \times (1 - .34)$

Thus,  $OCF_3 = \$720,833.33 + \$10,000 + \$6,600 = \mathbf{\$737,433.33}$

# Dorm Beds “Base-Case” NPV

---

First, set your calculator to 1 payment per year.

Then, use the cash flow menu:

CF0	-149,600	I	8
CF1	\$720,833.33	NPV	1,721,235.02
F1	2		
CF2	\$737,433.33		
F2	1		

# Dorm Beds Break-Even Analysis

---

- In this example, we should be concerned with break-even price.
- Let's start by finding the revenue that gives us a zero NPV.
- To find the break-even revenue, let's start by finding the break-even operating cash flow ( $OCF_{BE}$ ) and work backwards through the income statement.



# Dorm Beds Break-Even Analysis

---

The PV of the cost of this project is the sum of \$149,600 today less the \$16,600 salvage value and return of NWC in year 3.

CF0	-149,600	I	8
CF1	\$0	NPV	- 136,422.38
F1	2		
CF2	\$16,600		
F2	1		

# Break-Even Analysis: $OCF_{BE}$

---

First, set your calculator to 1 payment per year.

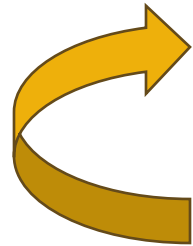
Then find the operating cash flow the project must produce each year to break even:

N	3
I/Y	8
PV	- 136,422.38
PMT	<b>52,936.46</b>
FV	0

# Break-Even Revenue

Work backwards from  $OCF_{BE}$  to Break-Even Revenue

Revenue	$10,000 \times \$P_{BE} =$	\$988,035.04
Variable cost	$10,000 \times \$90 =$	\$900,000
Fixed cost		\$25,000
Depreciation	$100,000 \div 3 =$	<u>\$33,333</u>
EBIT		\$29,701.71
Tax (34%)	$\frac{\$19,603.13}{0.66}$	<u>\$10,098.58</u>
Net Income		\$19,603.13
	$OCF = \$19,603.13 + \$33,333$	<b>\$52,936.46</b>



# Break-Even Analysis

---

- Now that we have break-even revenue we can calculate break-even price
- If we sell 10,000 beds, we can reach break-even revenue with a price of only:

$$P_{BE} \times 10,000 = \$988,035.34$$

$$P_{BE} = \$98.80$$

# Common Mistake in Break-Even

---

- What's wrong with this line of reasoning?
- With a price of \$200 per bed, we can reach break-even revenue with a sales volume of only:

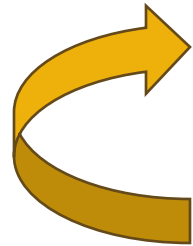
$$\text{Break - even sales volume} = \frac{\$988,035.04}{\$200} = 4,941 \text{ beds}$$

**As a check, you can plug 4,941 beds into the problem and see if the result is a zero NPV.**

# *Don't Forget that Variable Cost Varies*

---

Revenue	$Q_{BE} \times \$200 =$	$\$88,035.04 + Q_{BE} \times \$110$	
Variable cost	$Q_{BE} \times \$90 =$		\$?
Fixed cost			\$25,000
Depreciation	$100,000 \div 3 =$		<u>\$33,333</u>
EBIT			\$29,701.71
Tax (34%)	$\frac{\$19,603.13}{0.66}$		<u>\$10,098.58</u>
Net Income			\$19,603.13
	$OCF = \$19,603.13 + \$33,333$		\$52,936.46



# Break-Even Analysis

---

- With a contribution margin of \$110 per bed, we can reach break-even revenue with a sales volume of only:

$$Q_{BE} = \frac{\$88,035.04}{\$110} = 801 \text{ beds}$$

- If we sell 10,000 beds, we can reach break-even gross profit with a contribution margin of only \$8.80:

$$CM_{BE} \times 10,000 = \$88,035.04$$

$$CM_{BE} = \$8.80$$

- If variable cost = \$90, then  $P_{BE} = \$98.80$

# Break-Even Lease Payment

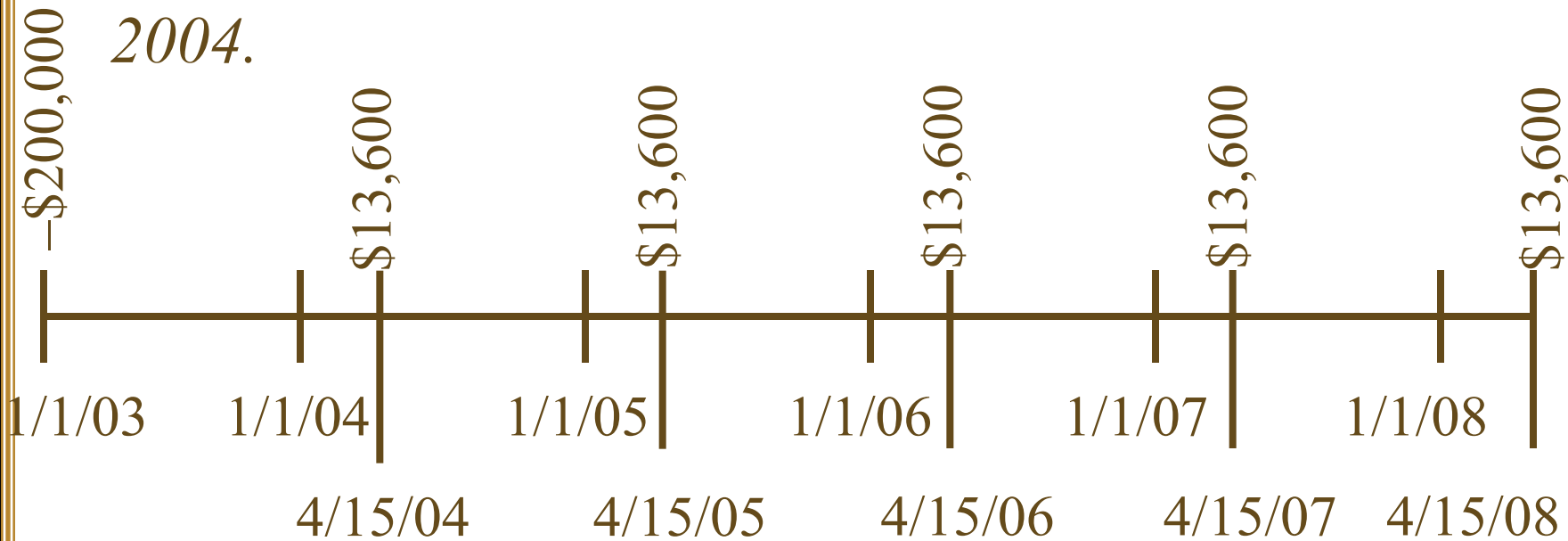
---

Joe Machens is contemplating leasing the University of Missouri a fleet of 10 minivans. The cost of the vehicles will be \$20,000 each. Joe is in the 34% tax bracket; the University is tax-exempt. Machens will depreciate the vehicles over 5 years straight-line to zero. There will be no salvage value. The discount rate is 7.92% per year APR. They pay their taxes on April 15 of each year. Calculate the smallest MONTHLY lease payment that Machens can accept. Assume that today is January 1, 2003 and the first payment is due on January 31, 2003



# Break-Even Lease Payment: Depreciation

- Let's cash flow this out from Joe's perspective.
- The operating cash flow at time zero is  $-\$200,000$ .
- The depreciation tax shields are worth  $0.34 \times \$40,000 = \$13,600$  each April 15, *beginning in 2004*.



# Present Value of Depreciation Tax Shield

---

The PV of the depreciation tax shields on April 15, 2003 is \$54,415.54.

N	5
I/Y	7.92
PV	-54,415.54
PMT	13,600
FV	0

# Present Value of Depreciation Tax Shield

---

The PV of the depreciation tax shields on January 1 2003 is \$53,176.99

N	3.5
I/Y	7.92
PV	53,176.99
PMT	0
FV	-54,415.54

## Where we're at so far:

---

- The cars do not cost Joe Machens \$200,000.
- When we consider the present value of the depreciation tax shields, they only cost Joe

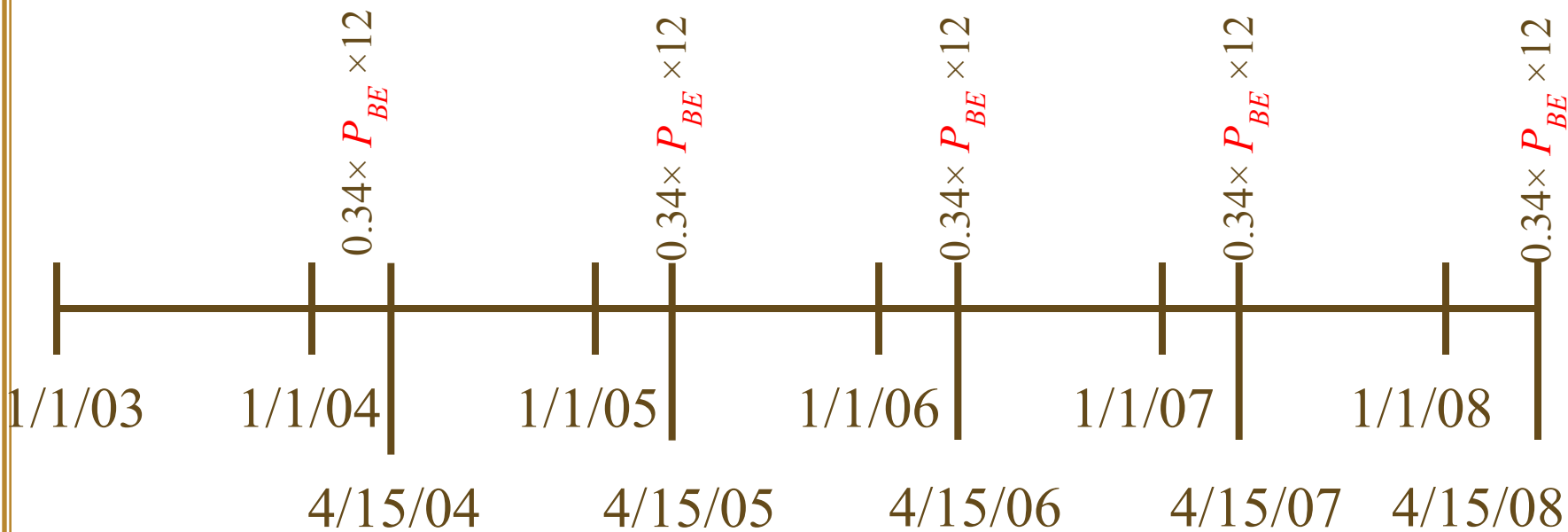
$$\$200,000 - \$53,176.99 = \$146,823.01$$

- Had there been salvage value it would be even less.
- Now we need to find out how big the price has to be each month for the next 60 months.
- First let's find the PV of our tax liabilities; then we'll find the PV of our gross income.

## Step Two: Taxes

- Recall that taxes are paid each April 15.  
Joe has to pay taxes *on last year's income*
- Taxes are  $0.34 \times P_{BE} \times 12$

Due each April 15, beginning in 2004 since our first year's income is 2003



This has a  $PV = 15.95 \times P_{BE}$

# Present Value of Tax Liability

---

The PV of the tax liability is 16.32 times one month's gross revenue *on 15 April 2003*.

N	5
I/Y	7.92
PV	$16.32 \times P_{BE}$
PMT	$-12 \times 0.34 \times P_{BE}$
FV	

# Present Value of Tax Liability

---

The PV of the tax liability on January 1 2003 is 15.95 times the value of one month's gross income

N	3.5
I/Y	7.92
PV	$15.95 \times P_{BE}$
PMT	0
FV	$16.32 \times P_{BE}$

# Solution: Payments

- In addition to the depreciation tax shields and income taxes,

Joe gets paid  $P_{BE}$  once a month for 60 months

Even though we don't know the dollar amount of  $P_{BE}$  yet, we can find the present value interest factor of \$1 a month for 60 months and multiply that (turns out to be 49.41) by  $P_{BE}$





# Present Value of Gross Revenue

---

The PV of 60 months of gross revenue on January 1 2003 is 49.41 times one month's gross revenue

N	60
I/Y	7.92
PV	$49.41 \times P_{BE}$
PMT	$-1 \times P_{BE}$
FV	

## Solution (continued)

---

- So the least Joe can charge is:

$$\$200,000 - \$53,176.99 =$$

$$\$146,823.01 = \$P_{BE} \times 49.41 - \$P_{BE} \times 15.95)$$

 <p>Cost of Cars net of Depreciation Tax Shield</p>	 <p>PV of Gross Revenue</p>	 <p>PV of Tax liability</p>
--	--	--

$$P_{BE} = \$4,387.80$$

(\$438.78 per month per car for a fleet of 10 cars)

# Summary Joe Machens

---

- This problem was a bit more complicated than previous problems because of the asynchronous nature of our tax liabilities.
- We get paid every month, but pay taxes once a year, starting in 3½ months.
- **Other than that, this problem is just like any other break-even problem:**
  - Find the true cost of the project (\$146,823.01)
  - Find the price that gives you an incremental after tax cash flow with that present value.

## 8.3 Monte Carlo Simulation

---

- Monte Carlo simulation is a further attempt to model real-world uncertainty.
- This approach takes its name from the famous European casino, because it analyzes projects the way one might analyze gambling strategies.

## 8.3 Monte Carlo Simulation

---

- Imagine a serious blackjack player who wants to know if he should take the third card whenever his first two cards total sixteen.
  - He could play thousands of hands for real money to find out.
  - This could be hazardous to his wealth.
  - Or he could play thousands of practice hands to find out.
- Monte Carlo simulation of capital budgeting projects is in this spirit.

## 8.3 Monte Carlo Simulation

---

- Monte Carlo simulation of capital budgeting projects is often viewed as a step beyond either sensitivity analysis or scenario analysis.
- Interactions between the variables are explicitly specified in Monte Carlo simulation, so at least theoretically, this methodology provides a more complete analysis.
- While the pharmaceutical industry has pioneered applications of this methodology, its use in other industries is far from widespread.

## 8.4 Options

---

- One of the fundamental insights of modern finance theory is that options have value.
- The phrase “We are out of options” is surely a sign of trouble.
- Because corporations make decisions in a dynamic environment, they have options that should be considered in project valuation.

# Options

---

- The Option to Expand
  - Has value if demand turns out to be higher than expected.
- The Option to Abandon
  - Has value if demand turns out to be lower than expected.
- The Option to Delay
  - Has value if the underlying variables are changing with a favorable trend.



# The Option to Expand

---

- Imagine a start-up firm, Campusteria, Inc. which plans to open private (for-profit) dining clubs on college campuses.
- The test market will be your campus, and if the concept proves successful, expansion will follow nationwide.
- Nationwide expansion, if it occurs, will occur in year four.
- The start-up cost of the test dining club is only \$30,000 (this covers leaseholder improvements and other expenses for a vacant restaurant near campus).

# Campusteria *pro forma* Income Statement

Investment	Year 0	Years 1-4
Revenues		\$60,000
Variable Costs		(\$42,000)
Fixed Costs		(\$18,000)
Depreciation		(\$7,500)
Pretax profit		(\$7,500)
Tax shield 34%		\$2,550
Net Profit		-\$4,950
Cash Flow	-\$30,000	\$2,550

$$NPV = -\$30,000 + \sum_{t=1}^4 \frac{\$2,550}{(1.10)^t} = -\$21,916.84$$

We plan to sell 25 meal plans at \$200 per month with a 12-month contract.

Variable costs are projected to be \$3,500 per month.

Fixed costs (the lease payment) are projected to be \$1,500 per month.

We can depreciate our capitalized leaseholder improvements.

# The Option to Expand: Valuing a Start-Up

---

- Note that while the *Campusteria test site* has a negative NPV, we *are* close to our break-even level of sales.
- *If* we expand, we project opening 20 *Campusterias* in year four.
- *The value of the project is in the option to expand.*
- If we hit it big, we will be in a position to score large.
- We won't know if we don't try.

# Discounted Cash Flows and Options

---

- We can calculate the market value of a project as the sum of the NPV of the project without options and the value of the managerial options implicit in the project.

$$M = NPV + Opt$$

- A good example would be comparing the desirability of a specialized machine versus a more versatile machine. If they both cost about the same and last the same amount of time the more versatile machine is more valuable because it comes with options.

# The Option to Abandon: Example

---

- Suppose that we are drilling an oil well. The drilling rig costs \$300 today and in one year the well is either a success or a failure.
- The outcomes are equally likely. The discount rate is 10%.
- The *PV* of the successful payoff at time one is \$575.
- The *PV* of the unsuccessful payoff at time one is \$0.

# The Option to Abandon: Example

---

Traditional NPV analysis would indicate rejection of the project.

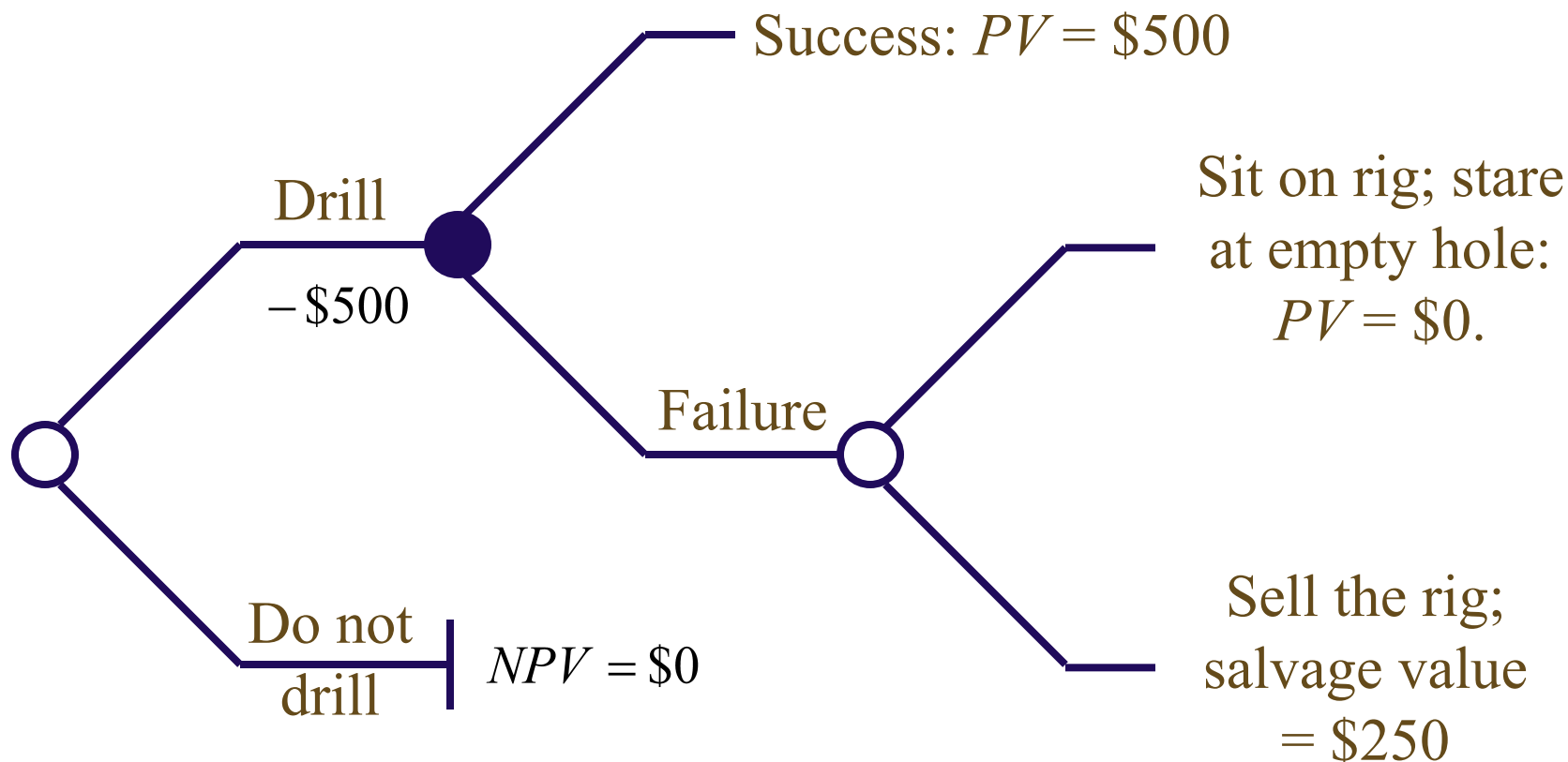
$$\text{Expected Payoff} = \text{Prob. Success} \times \text{Successful Payoff} + \text{Prob. Failure} \times \text{Failure Payoff}$$

$$\text{Expected Payoff} = (0.50 \times \$575) + (0.50 \times \$0) = \$287.50$$

$$NPV = -\$300 + \frac{\$287.50}{1.10} = -\$38.64$$

# The Option to Abandon: Example

Traditional NPV analysis overlooks the option to abandon.



*The firm has two decisions to make: drill or not, abandon or stay.*

# The Option to Abandon: Example

---

- When we include the value of the option to abandon, the drilling project should proceed:

$$\text{Expected Payoff} = \text{Prob. Success} \times \text{Successful Payoff} + \text{Prob. Failure} \times \text{Failure Payoff}$$

$$\text{Expected Payoff} = (0.50 \times \$575) + (0.50 \times \$250) = \$412.50$$

$$NPV = -\$300 + \frac{\$412.50}{1.10} = \$75.00$$



# Valuation of the Option to Abandon

---

- Recall that we can calculate the market value of a project as the sum of the NPV of the project without options and the value of the managerial options implicit in the project.

$$M = NPV + Opt$$

$$\$75.00 = -\$38.61 + Opt$$

$$\$75.00 + \$38.61 = Opt$$

$$Opt = \$113.64$$

# The Option to Delay: Example

<i>Year</i>	<i>Cost</i>	<i>PV</i>	<i>NPV<sub>t</sub></i>	<i>NPV<sub>0</sub></i>
0	\$ 20,000	\$ 25,000	\$ 5,000	\$ 5,000
1	\$ 18,000	\$ 25,000	\$ 7,000	\$ 6,364
2	\$ 17,100	\$ 25,000	\$ 7,900	\$ 6,529
3	\$ 16,929	\$ 25,000	\$ 8,071	\$ 6,064
4	\$ 16,760	\$ 25,000	\$ 8,240	\$ 5,628

$$\$6,529 = \frac{\$7,900}{(1.10)^2}$$

- Consider the above project, which can be undertaken in any of the next 4 years. The discount rate is 10 percent. The present value of the benefits at the time the project is launched remain constant at \$25,000, but since costs are declining the NPV at the time of launch steadily rises.
- The best time to launch the project is in year 2—this schedule yields the highest NPV when judged today.

## 8.5 Summary and Conclusions

---

- This chapter discusses a number of practical applications of capital budgeting.
- We ask about the sources of positive net present value and explain what managers can do to create positive net present value.
- Sensitivity analysis gives managers a better feel for a project's risks.
- Scenario analysis considers the joint movement of several different factors to give a richer sense of a project's risk.
- Break-even analysis, calculated on a net present value basis, gives managers minimum targets.
- The hidden options in capital budgeting, such as the option to expand, the option to abandon, and timing options were discussed.