

conventional investment decision methods

Lecture 4

Chapter Outline

- * **Uncertainty and Investment Analysis**
 - * The Investment Process with Risky Cash Flows
 - * Example: The Earthilizer Proposal
- * **Sensitivity Analysis**
 - * Scenario Analysis
 - * Breakeven Sensitivity Analysis
 - * Simulation Analysis
 - * Interpreting Simulation Results
 - * Reflections on the Use of Simulation
- * **Decision Trees—Valuing Project Flexibility**
 - * Example: Analysis of the Abandonment Option

Introduction

- * Investment decisions take place in a world of uncertain future outcomes
 - * There are **more things that can happen than will happen**
 - * Project Risk Analysis Confronts Uncertainty
- * Risk analysis and uncertainty
 - * Scenario analysis, breakeven sensitivity analysis, and Monte Carlo simulation
- * Importance of Flexibility
 - * The role of investment flexibility can affect the expected cash flows (Decision Trees)

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Earthilizer Example

- * New organic fertilizer made from dairy farm waste
- * Developed by CSM's ag-division in response to:
 - * Growing demand from organic farmers
 - * More restrictions on the disposal of cattle manure
- * Initial investment of \$580K required
 - * 250K WC + \$330K PPE
- * Project will be "up and running" by the end of 2007, with first year of sales in 2008
- * CSM financed internally (all-equity-financed)
- * Very promising investment opportunity
 - * Product has undergone extensive testing
 - * Product is wholly organic and cheaper (\$25 vs. \$20 / acre)

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Discounted Cash Flow Valuation (DCF)

- * DCF valuation analysis is simple:
 - * The value of an investment is determined by the magnitude and the timing of the cash flows it is expected to generate.
 - * The DCF approach provides a basis for assessing the value of these cash flows
 - * It is a cornerstone of financial analysis.

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Earthilizer Assumptions

- | | |
|---|--|
| <ul style="list-style-type: none"> * \$580K initial investment at the end of 2007 <ul style="list-style-type: none"> * \$250K WC and \$330 PPE * Sales \$1 million in 2008 <ul style="list-style-type: none"> * growing 10% annually throughout the 5-year planning period * COGS margin 67.40% * Operating expenses before depreciation are 10% of sales plus an annual fixed \$115K | <ul style="list-style-type: none"> * Straight-line depreciation <ul style="list-style-type: none"> * PPE 10-year life * zero salvage value * 30% tax rate * 2008 - 2012 NWC requirements = 25% of Earthilizer's sales * CAPEX \$330K in 2007 <ul style="list-style-type: none"> * zero in all future years * Project end = 2012 <ul style="list-style-type: none"> * Terminal cash flow: \$692,050 |
|---|--|

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Earthilizer: Income Statement

	2008	2009	2010	2011	2012
Sales	\$ 1,000.00	\$1,100.00	\$1,210.00	\$1,331.00	\$1,464.10
Cost of goods sold	\$ (674.00)	\$ (741.40)	\$ (815.54)	\$ (897.09)	\$ (986.80)
Gross profit	\$ 326.00	\$ 358.60	\$ 394.46	\$ 433.91	\$ 477.30
Operating expenses less depreciation	\$ (215.00)	\$ (225.00)	\$ (236.00)	\$ (248.10)	\$ (261.41)
Depreciation	\$ (33.00)	\$ (33.00)	\$ (33.00)	\$ (33.00)	\$ (33.00)
EBIT	\$ 78.00	\$ 100.60	\$ 125.46	\$ 152.81	\$ 182.89
Interest	\$ -	\$ -	\$ -	\$ -	\$ -
EBT	\$ 78.00	\$ 100.60	\$ 125.46	\$ 152.81	\$ 182.89
Taxes	\$ (23.40)	\$ (30.18)	\$ (37.64)	\$ (45.84)	\$ (54.87)
Net Income	\$ 54.60	\$ 70.42	\$ 87.82	\$ 106.96	\$ 128.02

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Earthilizer: Balance Sheet

	2007	2008	2009	2010	2011	2012
Net working capital	\$ 250.00	\$ 250.00	\$ 275.00	\$ 302.50	\$ 332.75	\$ 366.03
Gross plant and equipment	\$ 330.00	\$ 330.00	\$ 330.00	\$ 330.00	\$ 330.00	\$ 330.00
Less: Accumulated Depreciation	\$ -	\$ (33.00)	\$ (66.00)	\$ (99.00)	\$ (132.00)	\$ (165.00)
Net plant and equipment	\$ 330.00	\$ 297.00	\$ 264.00	\$ 231.00	\$ 198.00	\$ 165.00
Total	\$ 580.00	\$ 547.00	\$ 539.00	\$ 533.50	\$ 530.75	\$ 531.03

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Earthilizer: Project Free Cash Flows

	2007	2008	2009	2010	2011	2012
EBIT	\$ -	\$ 78.00	\$ 100.60	\$ 125.46	\$ 152.81	\$ 182.89
Less: Taxes	\$ -	\$ (23.40)	\$ (30.18)	\$ (37.64)	\$ (45.84)	\$ (54.87)
NOPAT	\$ -	\$ 54.60	\$ 70.42	\$ 87.82	\$ 106.96	\$ 128.02
Plus: Depreciation expense	\$ -	\$ 33.00	\$ 33.00	\$ 33.00	\$ 33.00	\$ 33.00
Less: CAPEX	\$ (330.00)	\$ -	\$ -	\$ -	\$ -	\$ -
Less: Changes in net working capital	\$ (250.00)	\$ -	\$ (25.00)	\$ (27.50)	\$ (30.25)	\$ (33.28)
Plus: Liquidation of net working capital	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 366.03
Plus: Liquidation of PPE	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 165.00
Equals: Project free cash flows (PFCF)	\$ (580.00)	\$ 87.60	\$ 78.42	\$ 93.32	\$ 109.71	\$ 658.77

NPV (13.25%) = \$43,070

IRR = 15.36%

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Sensitivity Analysis

- * Phase I is complete: We have an NPV estimate of the Earthilizer investment
 - * How confident can we be that the project will unfold as we expect?
 - * What are the key value drivers of the project that the firm should monitor over the life of the investment to ensure its success?
- * In Phase II we use a variety of tools to address these concerns
 - * Scenario analysis
 - * Breakeven sensitivity analysis
 - * Simulation analysis

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Scenario Analysis

- * What would happen to the Earthilizer NPV if we applied a pessimistic estimate of the initial sales of \$500,000?
 - * DCF value drops to \$342,790
 - * Negative-NPV investment,
- * We could also analyze scenarios involving multiple sets of changes in assumptions and forecasts.
 - * Evaluate the project using optimistic and pessimistic estimates for the value drivers

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Scenario Analysis in Excel

- * Changes in 1 or 2 Value Drivers?
 - * Use Data Tables
- * Changes in multiple Value Drives
 - * Use Scenario Manager

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Break-even Analysis

- * If our Initial Sales > \$923 then we have a positive NPV *ceteris paribus*
- * Can be very useful in resolving disputes and focusing energy
 - * If everyone in the room believes Initial Sales are above 923 then there's no need to argue

	A	B	C	D	E	F
1		Sales Growth	10%		NPV	\$ -
2		Initial Sales	\$ 923			

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More Complex Scenarios

- * Data Tables and Break-even analysis is nice but you can only manipulate one or two inputs
- * Suppose that there are many things that we'd like to manipulate at once
 - * Sales Growth Rate
 - * Initial Sales Level
 - * Operating Expenses Rate
 - * Gross Profit Margin

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Scenario Summary

方案摘要		当前值:	Real Good	Real Bad	Most likely
可变单元格:					
\$C\$1		10.0%	15.0%	2.0%	11.0%
\$C\$2	\$ 1,000	\$ 1,000	\$ 1,500	\$ 800	\$ 1,000
\$C\$3		67.4%	60.0%	75.0%	62.5%
\$C\$4		10.0%	5.0%	12.5%	7.5%
结果单元格:					
NPV	\$	43.07	\$ 997.36	\$ (335.16)	\$ 273.28

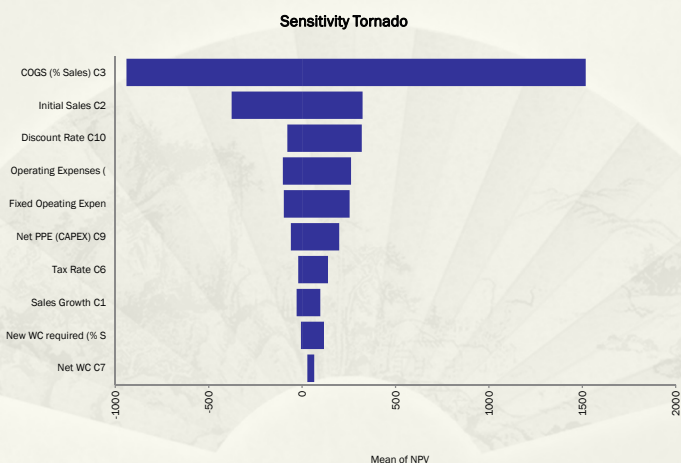
注释：“当前值”这一列表示的是在建立方案汇总时，可变单元格的值。
每组方案的可变单元格均以灰色底纹突出显示。

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Sensitivity Analysis (Tornado)

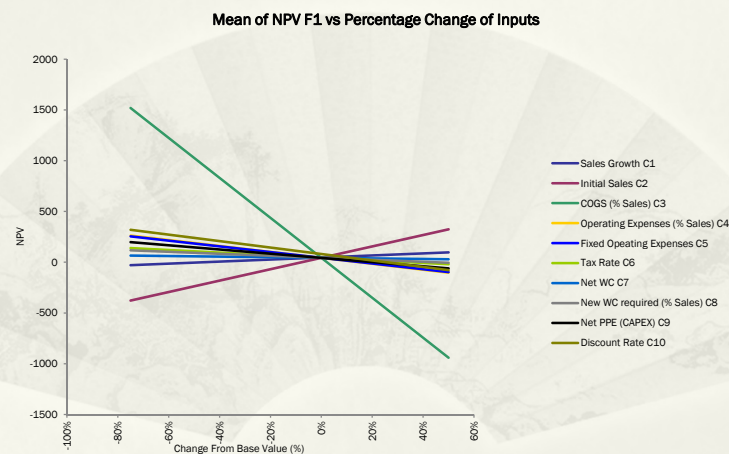


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Sensitivity Analysis



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Shortcomings

- * What is the probability of the NPV being at a certain level?
 - * Are all scenarios equally likely?
- * What is the relationship between input variables?
 - * Correlation
 - * High COGS/Sales → High Operating Costs

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Monte Carlo Simulation

- * Help the analyst evaluate what can happen to an investment's future cash flows and summarize the possibilities in a probability
 - * Outcomes from large projects are often the result of the interaction of a number of interrelated factors (or value drivers)
 - * Difficult to determine the probability distribution of a project's cash flows analytically
 - * Easy to find distribution via simulation

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Simulation Modeling Steps

- * Build a base case pro-forma
 - * No uncertainty
- * Characterize Input Probability Distributions
 - * Tornado chart to find key drivers
 - * Assess probability distributions
- * Sample many times and record outputs
 - * Statistical analysis of results
 - * Graphical analysis

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Earthilizer Input Distributions



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Extensions

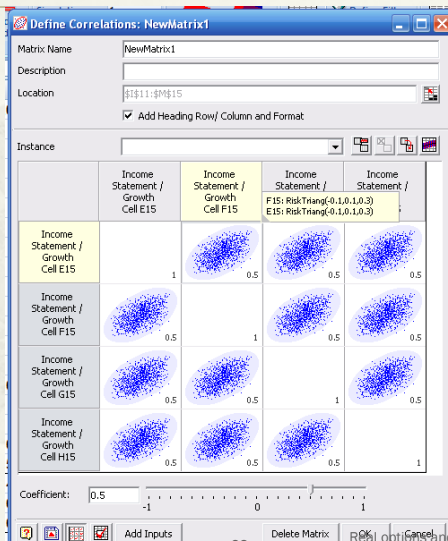
- * If project is successful early, should the growth rates reflect this?
- * Do our expenses move together?
 - * COGS and operating expenses
- * Mean reversion
 - * Tendency to correct
 - * Negative correlation in growth rates
- * Linking project value to macro-economy and other projects of the firm

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Visual Correlation Assessment



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Valuing Project Flexibility

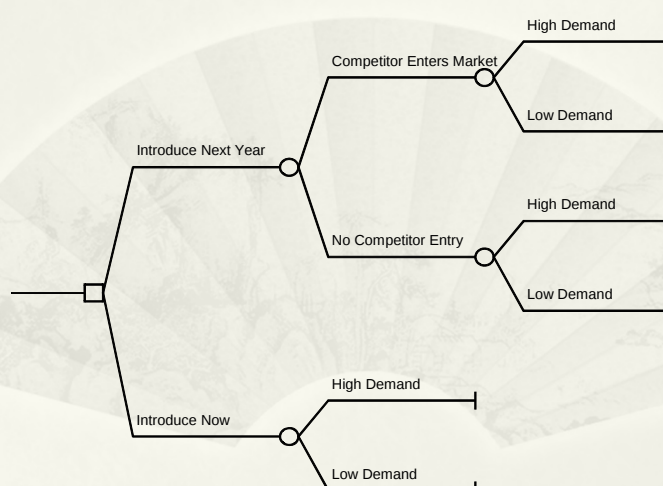
- * Most investment projects offer the firm some flexibility on the inputs used and final product produced
 - * Generate greater cash flows when market demand is high; cut back on capacity when market demand is low
- * Options associated with investments
 - * “Real” Options
 - * Decisions

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Introducing a New Product



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Earthilizer Abandonment Option

- * Assume CSM faces an EPA test of the runoff effects of Earthilizer on groundwater.
 - * Scenario 1: At end of year 1: EPA determines that the project poses no hazard; grants approval, no effect on project expected cash flows
 - * Scenario 2: EPA rules product detrimental; processing costs to CSM of \$80K per year (after taxes)
- * $\Pr(\text{Scenario 2}) = 0.20$

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Expected PFCFs

	2007	2008	2009	2010	2011	2012
Favorable EPA PFCF	\$(580.00)	\$ 87.60	\$ 78.42	\$ 93.32	\$109.71	\$658.77
NPV	\$ 43.07					
Unfavorable EPA PFCF	\$(580.00)	\$ 7.60	\$ (1.58)	\$ 13.32	\$ 29.71	\$578.77
NPV	\$(236.60)					
Expected PFCF	\$(580.00)	\$ 71.60	\$ 62.42	\$ 77.32	\$ 93.71	\$642.77
E[NPV]	\$ (12.87)					

* Expected PFCF

No Option to Abandon!

- * Weighted average of the original cash flows and the revised cash flows
- * $(1 - 0.2) \times \$87,600 + 0.2(\$87,600 - 80,000) = \$71,600$

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Option to Abandon

- * Can recoup \$380 of \$580 initial investment if we shut down after year 1

* Year 1 Cash flow = \$380 + 87.6 = \$467.6

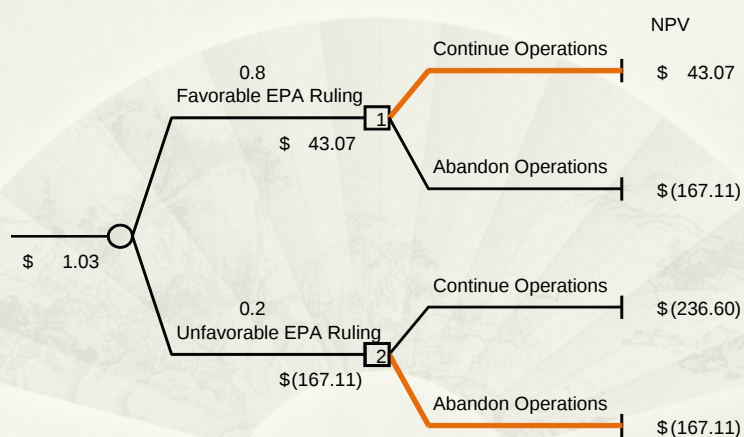
	2007	2008	2009	2010	2011	2012
Favorable EPA PFCF	\$(580.00)	\$ 87.60	\$ 78.42	\$ 93.32	\$109.71	\$658.77
Continue NPV	\$ 43.07					
Unfavorable EPA PFCF	\$(580.00)	\$467.60	\$ -	\$ -	\$ -	\$ -
Abandon NPV	\$(167.11)					
Expected PFCF	\$(580.00)	\$163.60	\$ 62.74	\$ 74.66	\$ 87.77	\$527.02
E[NPV]	\$ 1.03					

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Decision Tree Representation

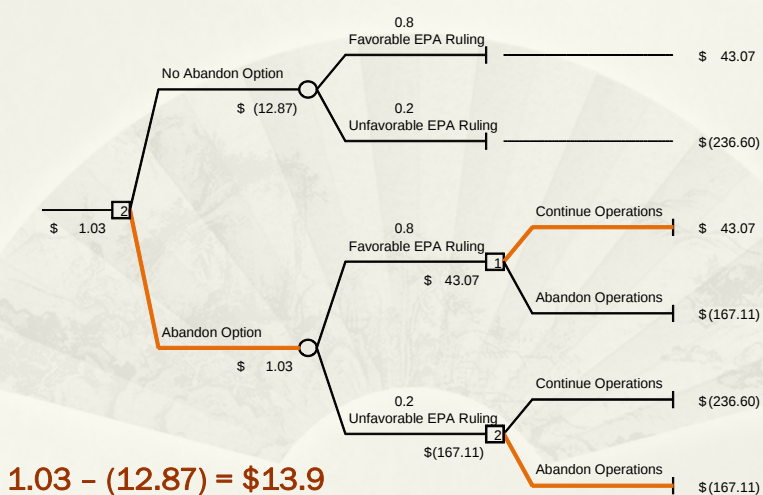


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What is the Option Worth?



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Summary

- * Determining the value of an investment opportunity is straightforward when future cash flows are known
- * Uncertainty complicates the valuation process
- * Analysts can utilize three basic tools to assess the impact of uncertainty on a project
 - * Scenario analysis, breakeven sensitivity analysis, and simulation analysis
 - * Provide information that the analyst can use to understand the key factors that drive a project's success or failure
- * Project flexibility allows firms to modify investments in response to changing circumstances
 - * More on real options later!

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期限不同的互斥投资决策

- * 考虑加拿大汽车公司（Canadian Motors）去年要求一家工程公司设计一款新的用于生产的机器。
 - * 工程公司提出了两种方案
 - * 较便宜的设计方案需要投入1000万美元，机器寿命为5年。
 - * 较贵的设计方案要投资1700万美元，机器寿命为10年。
 - * 在这两种情形下，预期这款机器可为加拿大汽车公司每年节约300万美元。
 - * 如果资本成本为10%，加拿大汽车公司应采纳哪种方案？

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期限不同的互斥投资决策

- * 考虑加拿大汽车公司（Canadian Motors）去年要求一家工程公司设计一款新的用于生产的机器。
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两种设计方案的净现值

- 短期设计方案的净现值为：

$$NPV = \frac{300}{0.1} \left(1 - \frac{1}{1.1^5} \right) - 1000 = 137 \text{ 万美元}$$

- 长期设计方案的净现值为：

$$NPV = \frac{300}{0.1} \left(1 - \frac{1}{1.1^{10}} \right) - 1700 = 143 \text{ 万美元}$$

- 如果分析师轻率地根据较高的净现值选择项目，则会选择机器寿命长的设计方案。然而，前面的净现值计算忽视了这两个项目寿命（或期限）的差异。

22-34

成本上升时的净现值

- 假定，5年后，一台新的、寿命短的、较便宜的机器的成本将变为1159万美元。
 - 到那时，用新机器替换旧机器所产生的净现值为：

$$NPV = \frac{300}{0.1} \left(1 - \frac{1}{1.1^5} \right) - 1159 = -22 \text{ 万美元}$$
 - 因为净现值为负，5年后用另一台寿命期短的新机器来代替同样的旧机器是不可行的，这意味着应该采纳寿命期长的方案。

22-35

未来成本不确定时的净现值

- 现实中，机器的未来成本往往是不确定的。这为加拿大汽车公司带来了放弃期权：
 - 只有当这样做有利时才需要替换寿命期短的设计方案。
- 假设短期设计中机器的成本或者逐年上升3%，或者下降3%。假设出现每种状态的风险中性概率均为50%。
- 那么在这种情况下，什么是最优的决策？

22-36

未来成本不确定时的净现值（续）

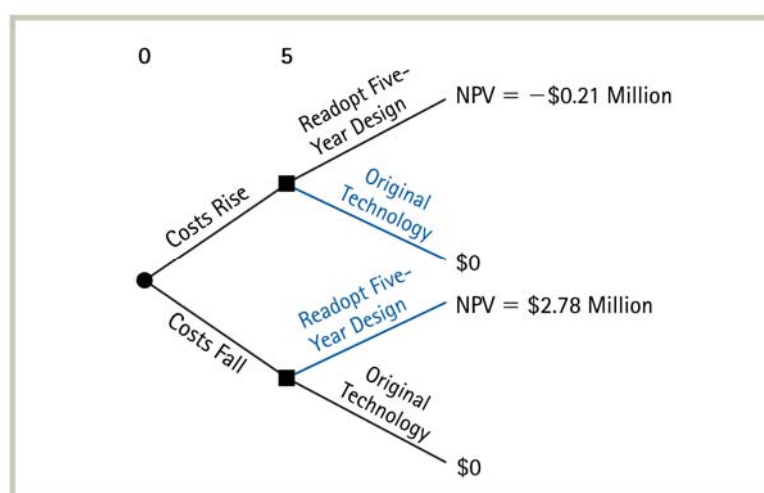
- 如果成本上升，加拿大汽车公司将不会替换旧机器，而会使用原来的技术。
- 如果成本下降，机器的成本将变为859万美元。
 - $10 \times (1 - 0.03)^5 = 859$ 万美元
- 那时，替换旧机器的净现值为：

$$NPV = \frac{300}{0.1} \left(1 - \frac{1}{1.1^5}\right) - 859 = 278 \text{ 万美元}$$

- 因此，采纳5年期设计方案的净现值，就等于使用机器满5年所产生的净现值，再加上5年后最佳替换旧机器的净现值。详见图22.10的决策树的描述。

22-37

22.10 5年期的设计方案



22-38

未来成本不确定时的净现值（续）

- 计算净现值如下：

$$NPV = 137 + \frac{0.50 \times 278}{1.1^5} = 223 \text{ 万美元}$$

- 现在，采纳5年期设计方案并且于5年后最优替换它所产生的净现值，超过了10年期设计方案的净现值，故5年期设计方案为较优的投资选择。

22-39

等价年收益法

- 等价年收益法
 - 在具有不同寿命期的项目中，选择等价年收益较高的项目的方法。
 - 它忽视了实物期权的价值，它仍然假设项目在期满后通常会按原先的条件被替换。

22-40

等价年收益法（续）

- 短期设计方案的净现值为137万美元。
 - 令 x 表示等价年收益。
 - 每年等价年收益的现值等于项目在今天的净现值。
 - 短期设计方案的等价年收益由下式给出：

$$1.37 = \frac{x}{0.1} \left(1 - \frac{1}{1.1^5} \right)$$

$$x = \frac{137 \times 0.1}{1 - \frac{1}{1.1^5}} = 36.1 \text{ 万美元}$$

22-41

等价年收益法（续）

- 重复上述计算，长期设计方案的等价年收益为：

$$1.43 = \frac{x}{0.1} \left(1 - \frac{1}{1.1^{10}} \right)$$

$$x = \frac{143 \times 0.1}{1 - \frac{1}{1.1^{10}}} = 23.3 \text{ 万美元}$$

- 基于等价年收益法的分析，分析师应选择机器寿命期短的设计方案。

22-42

22.7 经验法则

- 在应用本章所介绍的概念和方法时，存在着一个主要的缺陷就是难以实施。
 - 因此，很多公司寻求遵循经验法则来解决问题。

22-43

获利指数法则

- 获利指数法则
 - 指导你在获利指数超过某一事先确定的数值时进行投资。
 - 回顾一下，获利指数被定义为：

$$\text{Profitability Index} = \frac{\text{NPV}}{\text{Initial Investment}}$$
 - 存在延迟期权时，好的经验法则是，获利指数至少大于1时才进行投资。

22-44

预设回报率法则

- 预设回报率法则
 - 提高了折现率的标准。运用比资本成本更高的折现率来计算净现值，但另一方面依然遵循常规的净现值法则。
- 预设回报率
 - 一个用预设回报率法则产生的更高的折现率。
 - 如果项目能够跳过这一障碍，即以这一较高的折现率计算得到的净现值为正时，就应该被采纳。

22-45

预设回报率法则（续）

- 按揭贷款利率
 - 在任何时候可提前偿还（赎回）的无风险年金的利率。
- 若产生等待动机的不确定性来自于利率的不确定性，预设回报率由以下公司算得：

$$\text{Hurdle Rate} = \text{Cost of Capital} \times \frac{\text{Mortgage Rate}}{\text{Risk-Free Rate}}$$

22-46

图22.11 按揭贷款利率与无风险利率的历史比率



22-47

例22.2 预设回报率法则在延迟期权中的应用

- 问题：
 - 你拥有一项投资于无风险技术的机会。这项投资需要在初始时刻支付100万美元，投资后每年将产生96000美元的永续现金流。由于投资是无风险的，资本成本就是无风险利率。假设1年后，利率变为10%或6%的风险中性概率分别为64.375%和35.625%。1年期无风险利率为7%，无风险永久性债券的当前利率为8%。基于这些假设，等价的可提前偿还永久性债券的利率（按揭贷款利率）为9.6%。你会选择现在就投资，还是等到利率下降了再投资？

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例22.2 预设回报率法则在延迟期权中的应用 (续)

• 解答:

- 根据预设回报率经验法则，我们通过按揭贷款利率与无风险利率的比值，来放大资本成本。在此，现金流是无风险的，资本成本为无风险利率，这意味着预设的最低回报率就是按揭贷款利率。因此

$$NPV = \frac{96,000}{0.096} - 1,000,000 = 0 \text{ 美元}$$

- 依据经验法则，你对现在投资和等待这两种选择是中立的。我们来看看这是否正确。实际的资本成本为8%（基于无风险永续年金的利率），投资机会的净现值为：

$$NPV = \frac{96,000}{0.08} - 1,000,000 = \$200,000$$

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例22.2 预设回报率法则在延迟期权中的应用 (续)

• 解答:

- 再来分析等待的净现值是多少。如果延迟投资，利率下降时投资才是合理的，这是因为

$$NPV_{\text{利率上升}} = \frac{96,000}{0.1} - 1,000,000 = -40 \text{ 万美元}$$

$$NPV_{\text{利率下降}} = \frac{96,000}{0.06} - 1,000,000 = 60 \text{ 万美元}$$

- 使用风险中性概率计算得到期望净现值在今天的价值为：

$$\frac{600,000 \times 0.35625}{1.07} = 199,766 \approx 20 \text{ 万美元}$$

- 经验法则是正确的：今天投资和等待对你来说是无差异的。

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