Overview and Learning Objectives

Overview

We first discuss investment strategy as a means of identifying sources of value. We then move on to introduce several common financial analysis tools that are useful in managing the risk resulted from uncertainty in input forecasts. These financial analysis tools, including the sensitivity analysis, scenario analysis and breakeven analysis, are an invaluable part of every manager's toolkit. We conclude this chapter by discussing abandonment and delay options as representatives of the types of (real) options embedded in investment projects.

Learning Objectives

After reading course materials on this chapter, students should be able to:

- Identify sources and types of positive NPV projects.
- Utilize financial analysis and modeling appropriately in investment decision-making.
- Apply the decision tree analysis to analyze multiphase investment projects.
- Apply sensitivity analysis and scenario analysis techniques to refine the investment decision-making process.
- Explain the strengths and weaknesses of the sensitivity analysis and the scenario analysis.
- Apply the present value breakeven analysis to compute the level of price or sales quantity required for attaining zero net present value for the project.
- Explain the differences between the present value breakeven analysis and the accounting profit breakeven analysis, and the weaknesses of the latter in decision making.
- Identify the real options embedded in the projects and calculate their values.
- Make the right investment decision on projects with real options.

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Corporate Strategy and Positive NPV

Each of the following ways of creating positive NPV exploits imperfection in the market to deter competitors. The goods and service markets in which corporations operate are far less competitive and have many more market imperfections than the financial markets discussed in Chapter 9.

1. **Introduce a new product**
   - Apple Corporation and the mouse
   - Henry Ford's introduction of an affordable, mass-produced automobile.
2. **Develop a core technology**
   - Honda and small engines
   - 3M Corporation's mastery of sandpaper technology, which later developed into products ranging from photographic film to the ubiquitous 3M 'stick-em' notepads.
3. **Create a barrier to entry**
   - Qualcomm's patents on proprietary technology
   - As a regulated public utility, AT&T enjoyed monopoly power in the U.S. telecommunications industry for many decades.
4. **Introduce variations on existing products**
   - Chrysler's PT Cruiser
   - Lee Iacocca's notoriety began when he was instrumental in bringing the Ford Mustang to market while working for Ford Motor Company. The mechanical parts of the original Mustang were borrowed from existing Ford compact cars and then stylishly re-packaged for buyers wanting a low-priced sports car.
5. **Create product differentiation**
   - Coca-Cola – it's the real thing
   - Sears' Craftsman Tools are guaranteed for life. Sears will replace Craftsman Tools at no charge if damaged under normal use. This type of guarantee is common in businesses that attempt to differentiate their product according to quality.
6. **Utilize organizational innovation**
   - Motorola just-in-time inventory management
   - Amway International is well known for its innovative 'multi-level marketing' system. Other companies to successfully use this system include Tupperware and Mary Kay Cosmetics. Best-selling author Faith Popcorn (The Popcorn Report, New York, Doubleday, 1991) predicts that this marketing scheme will become increasingly popular in the future.
7. **Exploit a new technology**
   - Yahoo!'s use of banner advertisements on the web

These categories of "How to create positive NPV" are neither exhaustive nor mutually exclusive. They illustrate some common ways of identifying and exploiting positive-NPV investment alternatives.

Empirical studies focusing on the stock price reactions to corporate announcements of their investment decisions find that investors reward companies for investing in positive NPV projects and penalize companies for investing in value-destroying projects.

Corporate Strategy and the Stock Market

- There should be a connection between the stock market and capital budgeting.
- If the firm invests in a positive NPV project, the firm's stock price should go up.
- Sometimes the stock market provides negative clues as to a new project's NPV.
- Empirical Findings
  - McConnell & Muscarella (Journal of Financial Economics 1985)
  - Chan, Martin & Kensinger (Journal of Financial Economics 1990)
  - Woolridge (Journal of Applied Corporate Finance 1988)

Financial Analysis and Modeling in Investment Decision Making

Investment strategy is the key to every successful business. The financial analysis tools that follow (decision trees, sensitivity analysis, scenario analysis, and break-even analysis) cannot improve a poor investment. Used properly they can help bring into focus an existing investment proposal and help it reach its fullest potential. However, any analysis is subject to the law of GIGO (garbage-in-garbage-out) and these financial analysis tools can give a false sense of confidence if they are misused.

In practice, we usually construct financial models to analyze investment strategies. A financial model is an abstract of the real world. The correct way to construct a model should list all the assumptions explicitly. The assumptions of the Wild Kitty example that we will use in this chapter are:

1. Cost of the exploratory well
2. Cost of the production capacity
3. Expected future cash flows given the outcome of the exploratory well
4. Probability of success of the exploratory well
5. Production strategy (including the option to abandon)
6. Discount rate

These assumptions determine the inputs (information on costs, CF, probabilities, and discount rate) and the structure (production strategy) of the financial model. The financial analysis tools discussed in this chapter can be used to fine-tune the assumptions and strategies. The law of GIGO also applies to financial models. Common sense (sometimes called intuition) is a powerful tool against GIGO. When in doubt, we should always check the assumptions: Is an important variable omitted? Have the relationships between the variables changed? Are the strategies consistent (especially in a sequential decision problem)?

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Decision Trees (Ref: Section 7.4)

Decision trees are a convenient way of representing sequential decisions over time. Such decisions often arise when the uncertainty surrounding an investment can be reduced by some initial information-gathering such as test marketing a new product or preparing a feasibility study
(Slide).

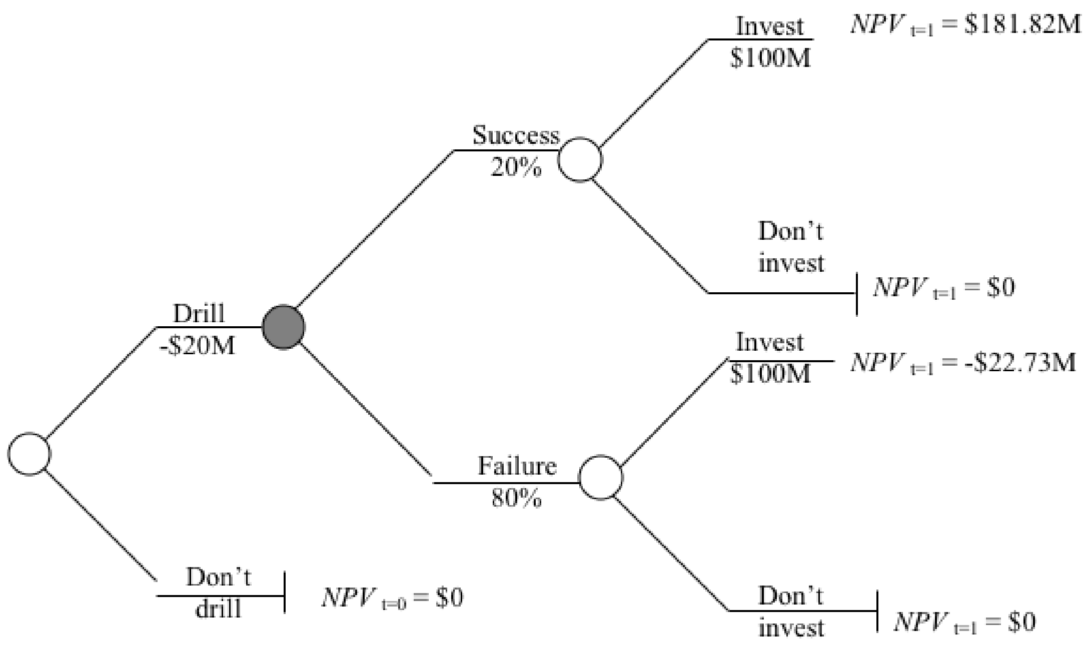
Example of a Decision Tree

Wild Kitty Drilling Company owns some land in Alaska, but is not sure if there is oil to be found. The land has no other commercial value. An exploratory well can be drilled today at a cost of $20 million. There is an 80% chance the exploratory well will come up dry. If the exploratory well is dry, there is still a chance that there is oil to be found. Whether the exploratory well is successful or not, production capacity can be installed in one year for $100 million. The discount rate for both phases of the project is estimated to be 10% (see Warning below).

Once production capacity is installed, the same amount of after-tax cash flow is expected to be generated in perpetuity. The actual amount will not be known until after production capacity is installed. If the exploratory well is successful, annual cash flow is expected to be $30M. If the exploratory well is unsuccessful, annual cash flow is expected to be $7.5M. Should Wild Kitty invest in the exploratory well?

The firm faces sequential decisions. Just as in solving a maze, it is easiest if we begin at the end and then move toward the start. The decision tree for Wild Kitty is shown below. The NPVs at the right-hand side represent the possible outcomes at t=2 and beyond, given different production decisions.

Decision Tree for Wild Kitty



Decision at t=1:

Given the possible outcomes in year 2, should production begin in one year, i.e., Year 1?

This decision is made at t=1. The NPVs provided on the far right side of the decision tree depend on the outcome of the exploratory well and the cost of the production capacity. The $20M of the exploratory well is a sunk cost at this point in time and does not affect the decision at t=1.

Consider the $181.82M expected NPV for production capacity given a successful exploratory well. The expected annual cash flow for years 2 and beyond given a successful exploratory well is $30M. The NPV (discounted back to t=0) of this expected perpetual cash flow less the cost of the production capacity is:

$E[NPV_{t=0}$ | successful exploratory well] = [$30M/0.1 − $100M] / (1 + 0.1) = **$181.82M**

On the other hand, the expected annual cash flow for years 2 and beyond given an unsuccessful exploratory well is $7.5M. The NPV (discounted back to t=0) of this expected perpetual cash flow less the cost of the production capacity is:

$E[NPV_{t=0}$ | unsuccessful exploratory well] = [$7.5M/0.1 − $100M] / (1 + 0.1)
= **-$22.73M**

Since the expected NPV when the exploratory well is unsuccessful will be less than $0, we will not invest in the production capacity. Note that not all the possible outcomes (and NPV) are included in the analysis. Once a decision is made, only the NPVs from the chosen paths should be included. In this example, the expected NPV is $181.82M if the exploratory well is successful and $0 if the well is unsuccessful. The path that results in NPV = -$22.73M will not be chosen and is therefore irrelevant.

Decision at t=0:

Should Wild Kitty dig an exploratory well today, i.e., t=0?

This decision (at t=0) depends on the possible outcomes at t=2 and beyond, given the decisions made at t=1. At this time (today), the firm has not invested in the exploratory well and its cost must be included in the analysis.

$E(NPV_{t=0})$ = (0.8 * $0 + 0.2 * $181.82M) − $20M = $16.36M

Warning: Different Discount Rates for Different Alternatives

This analysis assumes that the risks of the exploratory well and production capacity are the same. In sequential decisions, this is often not the case. The riskiness of this project may warrant a 10% discount rate as of time 0. Once the outcome of the exploratory well is known, the appropriate discount rate may be less.

Another Illustration: Stewart Pharmaceutical

- Stewart Pharmaceuticals Corporation is considering investing in the development of 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 following 4 years.

NPV 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

$$NPV_1 = -\$1{,}600 + \sum_{t=1}^{4} \frac{\$1{,}588}{(1.10)^t}$$

$$NPV_1 = \$3{,}433.75$$

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. Assume a cost of capital of 10%.

NPV 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	$475.90

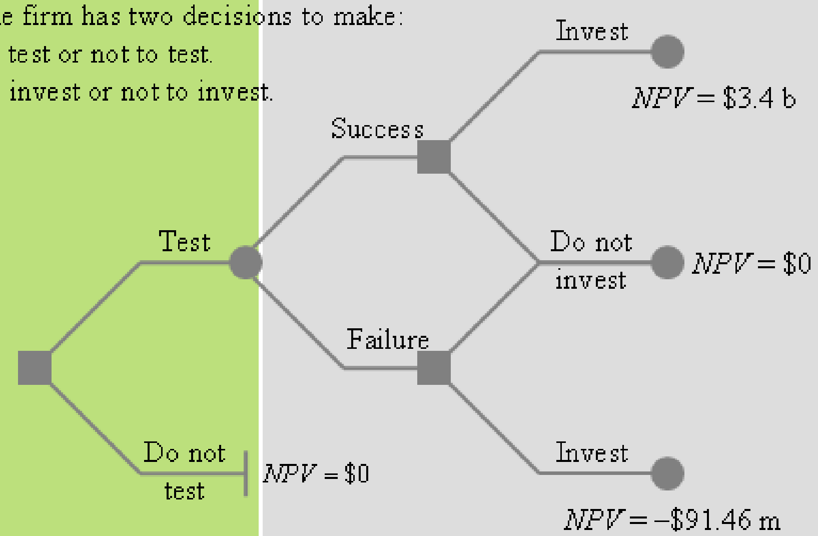
$$NPV_1 = -\$1{,}600 + \sum_{t=1}^{4} \frac{\$475.90}{(1.10)^t}$$

$$NPV_1 = -\$91.461$$

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. Assume a cost of capital of 10%.

Decision Tree for Stewart

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



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Decision to Test

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

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

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

The NPV evaluated at date 0 is:

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

So, we should test.

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Sensitivity Analysis and Scenario Analysis (Ref: Section 7.1)

Sensitivity Analysis

Sensitivity analysis looks at the sensitivity of a project's NPV to varying outcomes of a single variable. Sensitivity analysis serves many purposes. We discuss two common applications. First, sensitivity analysis helps us to focus on variables that have the greatest impact on the NPV of a project. For example, if a 1% change in revenue forecast results in a 50% change in project NPV, more time and effort should be spent in obtaining an accurate revenue forecast. On the other hand, if a 1% change in shipping costs result in a 0.01% change in project NPV, shipping costs should be a relatively low priority for the analyst. Second, sensitivity analysis can indicate whether NPV analysis should be trusted.

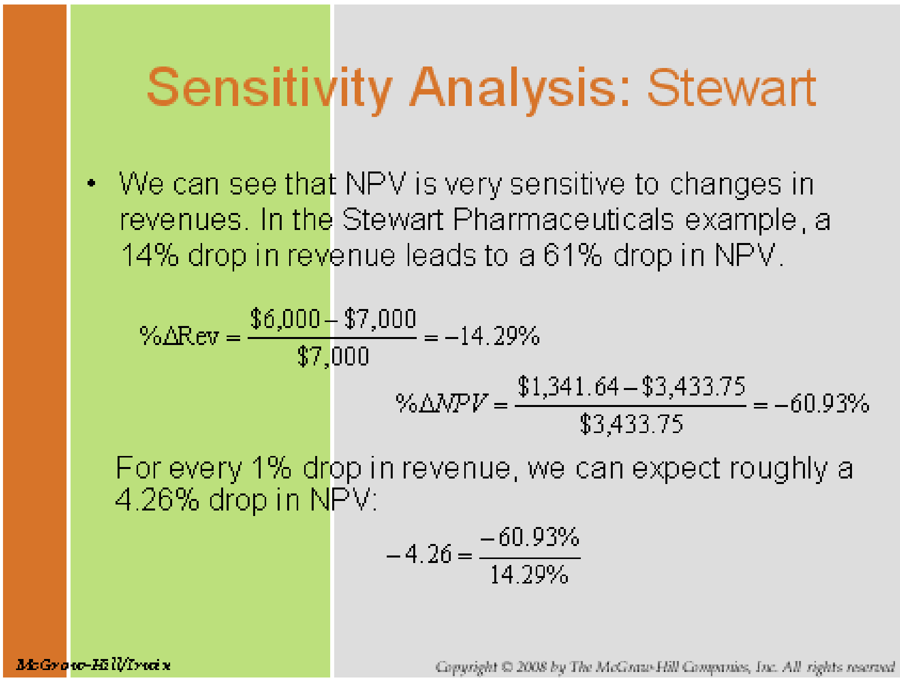
However, sensitivity analysis has its own weaknesses – First, it may increase the false sense of security in the capital budgeting analysis and decision because the management may still be overly optimistic in assessing the pessimistic case. Second, sensitivity analysis examines each input variable in isolation, and hence missing the interactions among input variables. This may understate the adverse impact of the unfavorable condition on the NPV of a project.

Example: Stewart Pharmaceutical

Investment	Year 1	Years 2-5
Revenues		\$6,000
Variable Costs		(3,000)
Fixed Costs		(1,800)
Depreciation		(400)
Pretax profit		\$800
Tax (34%)		(272)
Net Profit		\$528
Cash Flow	-\$1,600	\$928

$$NPV = -\$1{,}600 + \sum_{t=1}^{4} \frac{\$\ 928}{(1.10)^t} = \$1{,}341.64$$

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.



Scenario Analysis

Sensitivity analysis looks at the sensitivity of NPV to variation in a single variable. In contrast, scenario analysis allows several variables to change at once in an attempt to identify outcomes characteristic of, say, a most likely (or "best guess"), an optimistic, or a pessimistic scenario.

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

Monte Carlo Simulation (Ref: Section 7.2)

In a nutshell, Monte Carlo Simulation goes one step further in risk analysis by combining the distribution of each input variable in the sensitivity analysis with the consideraton of interactions among several input variables simultaneously in the scenario analysis. With the help of the computational power of computer, Monte Carlo Simulation generates a simulated distribution of the NPV of a project for the reference of management in their capital budgeting analysis and decision.

The authors have done a fine job in highlighting the typical procedures of a Monte Carlo Simulation in the text.

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Options (Ref: Section 7.3)

When evaluating investment strategies, it is important to recognize the options to expand or to abandon a project as more information is gathered and if business conditions change. Such (real) options are valuable because they give the holders, i.e., the company, the RIGHT, but not obligation, to do something to their advantages.

Intuitively, the value of the real option, **Opt**, can be considered as the difference between the value of the project with the embedded real option, **M** and the value of the project without the embedded real option, **NPV**!

Here are some common types of real options available to companies:

- The Option to Expand
  - It has a positive payoff if demand turns out to be higher than expected.
- The Option to Abandon
  - It has a positive payoff if demand turns out to be lower than expected.
- The Option to Delay (or Wait)
  - It has a positive payoff if the underlying variables are changing with a favorable trend.

Option to Abandon

The Decision Trees example (Wild Kitty) has an embedded option to abandon if future conditions turn unfavorable. Suppose when Wild Kitty purchased the land from the Alaskan government they had agreed to install the production capacity if they do any digging, including an exploratory well. With this contract, Wild Kitty must invest the $100M regardless of the outcome of the exploratory well. In other words, Wild Kitty no longer has the option to abandon the project. How does this contract affect the analysis?

Decision at t=1:

Wild Kitty has no choice. It must install the production capacity.

$E[NPV_{t=0} \mid \text{successful exploratory well}] = [\$30M/0.1 - \$100M] / (1+0.1) = \$181.82M$
$E[NPV_{t=0} \mid \text{unsuccessful exploratory well}] = [\$7.5M/0.1 - \$100M]/(1+0.1) = -\$22.73M$

Decision at t=0:

Should Wild Kitty dig an exploratory well today?

NPV: $E(NPV_{t=0}) = 0.8 * -\$22.73M + 0.2 * \$181.82M - \$20M = -\$1.82M$

Recall from the Decision Trees section that the expected NPV of the exploratory well was $16.36M in the original example where there's an embedded option to abandon, i.e., one can walk away from the exploratory well in the unsuccessful branch.

M: $E(NPV_{t=0}) = (0.8 * \$0 + 0.2 * \$181.82M) - \$20M = \$16.36M$

The expected NPV of the investment is higher when there is an option to abandon the project. We will abandon the project if the expected NPV is negative.

And we calculate the the value of this option to abandon (Opt), which is equal to the difference between the value of the project with (M) and the value of the project without the abandonment option (NPV) as

Opt = M − NPV = \$(16.36M − (-1.82M)) = \$18.18M.

Alternatively, we can calculate the value of this option to abandon (Opt) as:

$NPV_{t=0}$(Abandonment Option) = 0.8 * \$22.73M = \$18.18M

Another Illustration for the Option to Abandon

- 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.

Traditional NPV analysis would indicate rejection of the project (Slide).

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 = -38.64 + *Opt*
Opt = \$113.64

Option to Delay (or Wait)

In many cases, a company can delay the implementation of a project. As such, nearly every investment project must also compete with itself postponed. Moreover, the effect of interest rate uncertainty on the optimal investment delay is sizable. Therefore, the traditional textbook NPV rule that suggests accepting all positive-NPV projects may be incorrect given the option to wait.

Example on Option to Delay

Year	*Cost*	*PV*	*NPV $_t$*	*NPV $_0$*
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

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

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

M = NPV + Opt

In the previous example, the value of the option to delay the launching of the project by two years is

Opt = \$6,529 − \$5,000 = \$1,529

What is the value of the option to delay the launching of the project by four years?

Consider the above project, which can be undertaken in any of the next four years. The discount rate is 10%. 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.

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

- 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.

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

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

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.