## 7.12 Decision Analysis

**Decision Analysis** in a technique that is used when one has a situation that involves two or more decisions in sequence and at least one of the decisions leads to an outcome that the decision maker does not control—a ***random*** **outcome**. Random outcome is synonymous with random variable.

The "situation" is conceptualized by drawing a decision tree. The decision tree is the "guts" of Decision Analysis.

The **green square** is used to indicate a point where a decision must be made. The decision maker **controls** this point. There are no probabilities associated with decision points.

The **red circle** is used to indicate a point where the outcome is random. The decision maker **does not control** this point. There are probabilities associated with random outcome points.

The **blue triangle** is used to indicate a termination point, the decision process ends at this point.

The **green square** and **red circle** are used by most books in discussing Decision Analysis, the **blue triangle** is not always used.

Decision Analysis's Basic Creed is: **Be Proactive Rather Then Reactive in Your Decision Making.**

What this is saying is that, whenever possible, think ahead, plan, and create a strategy for how you will behave if and when you face a certain problem.

**It's Better to have a Planned Action than just to React.**

Decision Analysis proponents are telling us to move from being **Unstructured** in our decision making to being **Structured**.

**Doctors and Decision Analysis**
If we have an accident and go to an emergency room we want the doctor to have thought about and have a plan of action before we arrive, even though she doesn't know we are coming. How would you feel laying on the stretcher and having the doctor think, gee I've never seen this before nor have I ever thought of what to do in cases like this? Ideally in an emergency room we want the doctor to act quickly following a procedure they have thought about. It is not the time to explore and discover answers.
**Lawyers and Decision Analysis**
Lawyers are constantly making decision for clients. Should we go to court or settle out of court? We certainly hope they know how to gather facts, create information and know how to use the information to make the correct decision regarding our case.

It may surprise you that very few medical or law schools formally teach decision making. The schools assume that good decision making will just happen. We don't feel it always does, and that by formally studying decision making we can improve the effectiveness and efficiency of the decision being made.

**To Market or Not to Market**

A company has developed a new product that they have patented. They believe that the product will only sell for one year, as new technology will make it obsolete. After much discussion both with other companies and in-house, they believe they have three possible alternatives.

**I.** They can sell the patent rights now for $1,500,000. This is a sure thing; the money is in escrow.

**II.** They can sell the rights to the product now for later royalties. Marketing has studied the company that would have the rights and that would build and market the product. The tables below indicates the opinions of total amount of royalty $. All royalty numbers are in million $.

| **Royalty** | **P(Royalty$)** |
|---|---|
| 0 | .3 |
| 2 | .5 |
| 3 | .2 |

**III.** They can try building it in-house. Production has indicated that they will try to build the product using their present equipment. They would make one production run of 1 million items. This would cost them $1 million and they are 80% confident they can do it. If Production fails, there is a second option. Production is 100% confident that by purchasing a new piece of equipment that would cost $700,000 and be worth nothing at the end of the year, they can produce the 1 million items. If production fails on the first attempt, you also have the alternative of selling the patent but at this time the patent would only be worth $800,000. The royalty would no longer be an option.

If production is successful the first time, marketing must decide between two marketing efforts; the tables indicate what they believe would happen.

| | **Sales** | **P(Sales$)** |
|---|---|---|
| $900,000 Advertising | 2 | .1 |
| | 4 | .6 |
| | 6 | .3 |

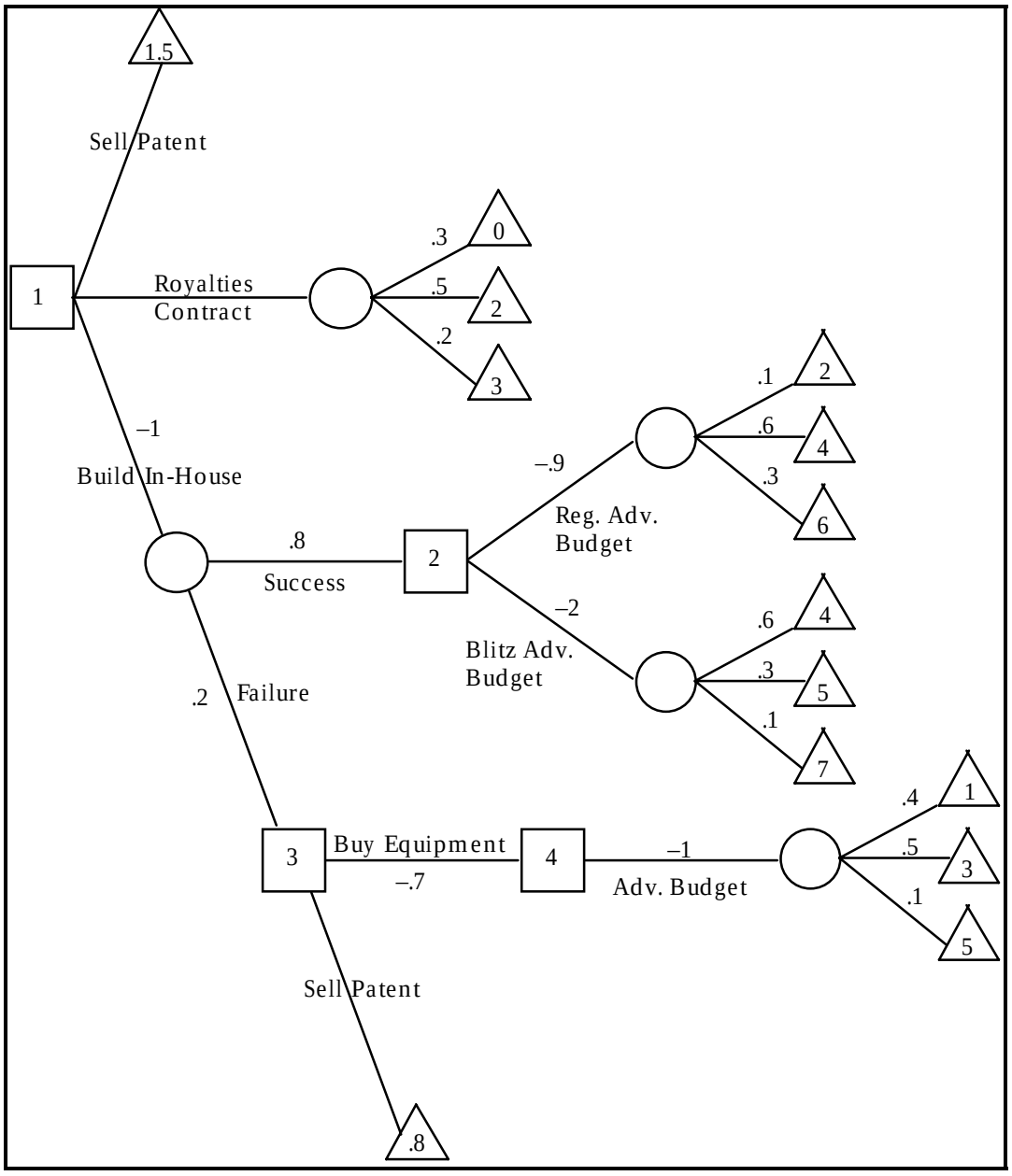
| | **Sales** | **P(Sales$)** |
|---|---|---|
| $2 million Advertising | 4 | .6 |
| | 5 | .3 |
| | 7 | .1 |

If Production is not successful on the first attempt and it is decided to purchase the new equipment, Marketing feels they will have time only for a $1 million advertising effort and sales will be less because of reduced time.

| **Sales** | **P(Sales$)** |
|---|---|
| 1 | .4 |
| 3 | .5 |
| 5 | .1 |

What should they do? Often, a student's first reaction is, "you've got to be kidding."
**Don't panic;** real life problems will take far more time than this one.

**First Step: Draw the Decision Tree Diagram**




The Decision Tree is simply a picture of the order in which "things" could happen. When the decision maker is in control of these "things," we use the **green square** when the decision number is not in control of these "things" we use the **red circle** and when the process will end we use the **blue triangle**.

**Second Step:** **We use the Decision Tree to determine our strategy: how we plan to behave.**

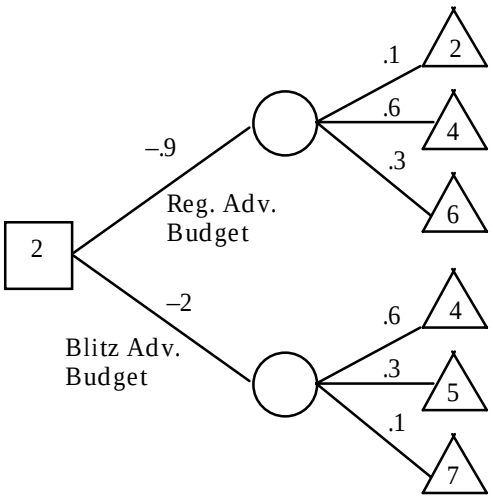
This requires that one establish a criteria for making decisions. One criterion that is often used in Decision Analysis is:

**We will always select the alternative that maximizes our expected profit.**

This is giving "structure" to how we will behave at decision points. We select the one that we believe will yield the highest average profit. You should recognize that this is consistent with how we analyze random variables. We know that in many situations we cannot determine what will happen, the outcome is **random**. We can, however, determine what will happen on **average**.

**Working Backwards**
The analysis requires that we start at the end of the diagram and work backwards. It is a great example of avoiding the **sunk cost** issue, as we are not influenced by what has gone on in the past. We look to the future and determine how we should behave at this decision.

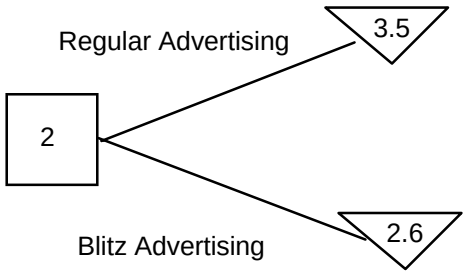
**Decision Point 2**
It is possible that we would face Decision Point 2 —how should we behave?
Since the outcomes are random, we reason out the average profit for each decision.




| Sales | P(Sales) | Sales • P(Sales) |
|---|---|---|
| 2 | .1 | .2 |
| 4 | .6 | 2.4 |
| 6 | .3 | 1.8 |
| | | E(Sales) = 4.4 |
| | | Cost = -.9 |
| | | **E(Profit) = 3.5** |

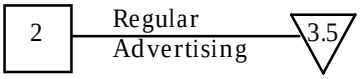
| Sales | P(Sales) | Sales • P(Sales) |
|---|---|---|
| 4 | .6 | 2.4 |
| 5 | .3 | 1.5 |
| 7 | .1 | .7 |
| | | E(Sales) = 4.6 |
| | | Cost = -2 |
| | | **E(Profit) = 2.6** |

This gives




If we are ever at Decision Point 2, we will do the regular advertising. Why? Because our analysis indicates this decision will maximize the expected profit and our stated criteria for deciding is:

**We will always select the alternative that maximizes our expected profit.**




The upside down triangle 

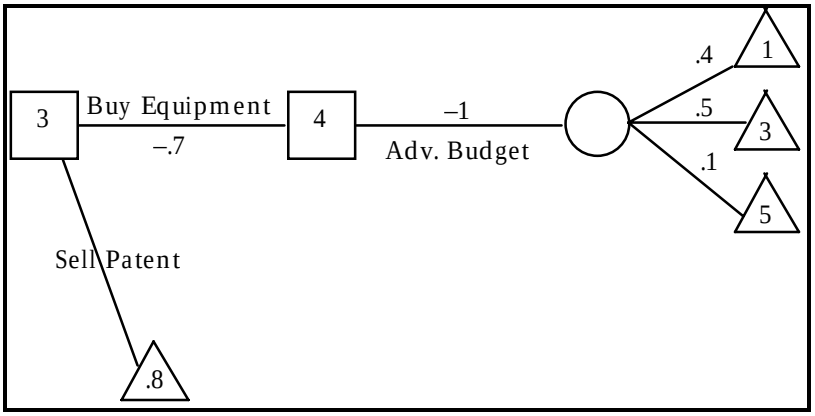
is not standard notation. We use the upside down triangle because we want to make the distinction between numbers that are **averages**, 

and numbers that are "sure things," e.g., 

. You will get 1.5 million for the patent. You would not get 3.5, the 3.5 is the opinion average of the estimated sales.

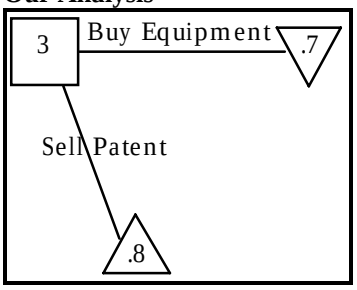
**Decision Point 3**

Note that we do not analyze Decision Point 4, because Marketing has said that at this point they believe there is only one path to take. We determine the expected profit for this decision.

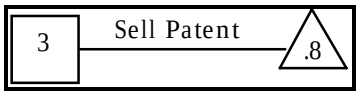



| Sales | P(Sales) | Sales • P(Sales) |
|---|---|---|
| 1 | .4 | .4 |
| 3 | .5 | 1.5 |
| 5 | .1 | .5 |
| | | E(Sales) = 2.4 |
| | | - Cost = -1.7 |
| | | **E(Profit) = .7** |

**Our Analysis**

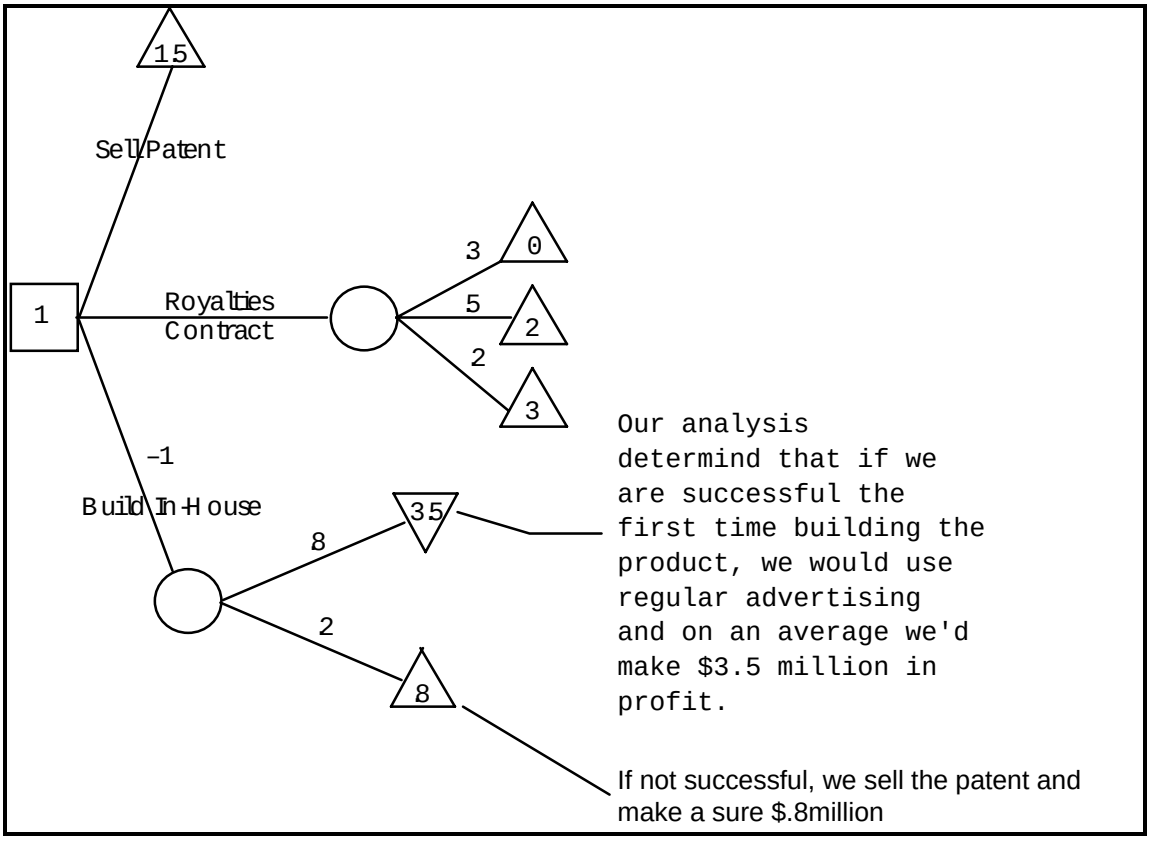


**Our Decision**




We always select the alternative that **maximizes our expected profit.**

**Decision Tree Has Been Trimmed Back**



**Further Reduction of Tree**

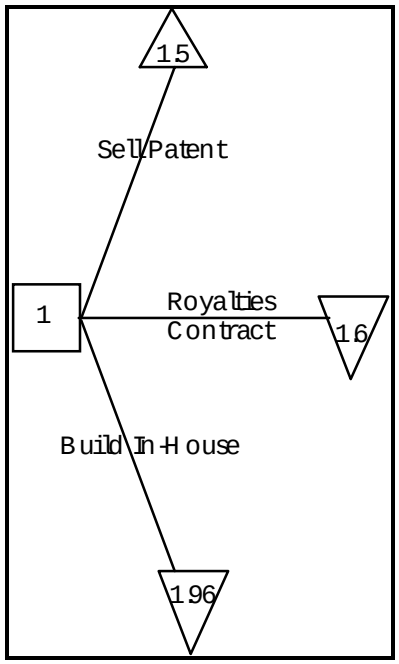
**Royalties Contract**

| Royalties | P(Royalties) | R • P(R) |
|---|---|---|
| 0 | .3 | 0 |
| 2 | .5 | 1.0 |
| 3 | .2 | .6 |
| | | **E(Royalties) = 1.6** |

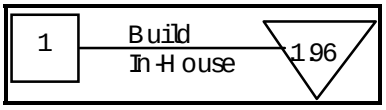
**Build In-House**

| Revenue | P(Revenue) | P • P(R) |
|---|---|---|
| 3.5 | .8 | 2.8 |
| .8 | .2 | .16 |
| | | E(Revenue) = 2.96 |
| | | -Cost = -1 |
| | | **E(Profit) = 1.96** |

**Our Analysis**



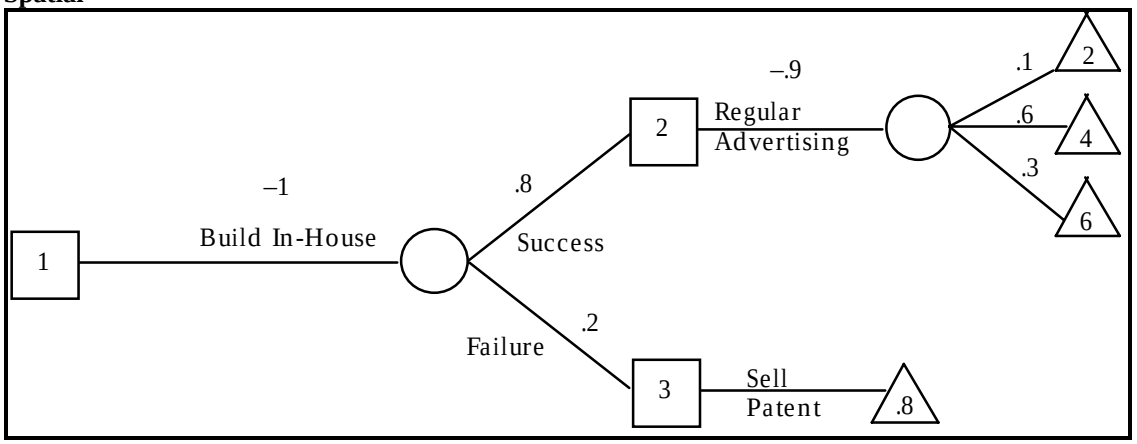

**Our Decision**



**Our Strategy**

Now we draw the Decision Tree of the **strategy** that was determined by the analysis.
A **strategy** is a **plan** that tells us how we will behave for the various situations we **could** face.

**Spatial**



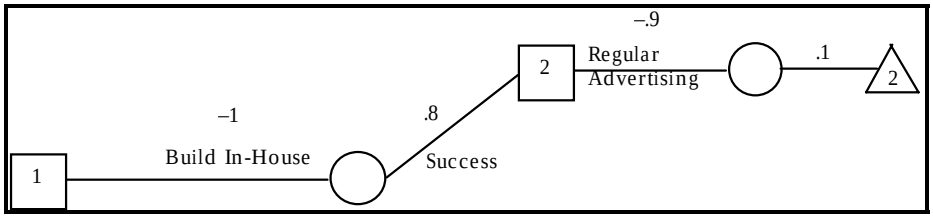

**Verbal** We will build-in house. If we are successful we will do regular advertising. If we fail building in-house, we will sell the patent.

**Step 3: Risk Analysis**

The **strategy** we have selected has both **risks and rewards** associated with it. **Risk Analysis** forces us to look at what can happen by following this strategy and what probabilities are associated with these risks and rewards.

We look at each outcome and assess the cost of that outcome and the probability of the outcome.

We work backwards from each **blue triangle** on the Decision Tree diagram found in Step 2. Make sure you understand where the numbers in the table below came from.




**Revenue** = **2** Number inside ✲ .

**Cost** = –1+(–.9) = –**1.9**

**Profit = Revenue - Cost** = 2 - 1.9 = **.1**

**P(Profit)** = P(Success) x P(Sales)

= .8 x .1

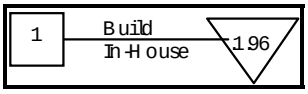
**P(Profit)** = **.08**

| **Revenue** | **Cost** | **Profit** | **P(Profit)** |
|---|---|---|---|
| 2 | 1.9 | 0.1 | .08 |
| 4 | 1.9 | 2.1 | .48 |
| 6 | 1.9 | 4.1 | .24 |
| .8 | 1 | -0.2 | .20 |
| | | | 1.00 |

The table shows us there is only a 20% chance that we will lose money. We estimate this loss to be $200,000. There is an 80% chance of making money, as much as $4,100,000 and as little as $100,000. We have **quantified the risks and rewards** of our strategy. What is the Expected Profit for the above table?

| **Profit** | **P(Profit)** | **Profit • P(Profit)** |
|---|---|---|
| .1 | .08 | .008 |
| 2.1 | .48 | 1.008 |
| 4.1 | .24 | .984 |
| -.2 | .20 | -.040 |
| | 1.00 | **E(Profit)=1.96** |

Refer back to the result of Step 2 – Our Decision




In working backwards we had reasoned out that on an average we would make 1.96 million with our strategy. The Risk Analysis shows us where this 1.96 average comes from.
Remember the statement: **What Evils Do Averages Hide?**

## Scenario

What if the Risk Analysis for the previous problem had been:

| Profit | P(Profit) | Profit • P(Profit) |
|---|---|---|
| -.04 | .999 | -.03996 |
| 1999.96 | .001 | 1.99996 |
| | 1.00 | **E(Profit)=1.96** |

Profit is again in millions of dollars and is the same expected profit, 1.96 million.

The Risk Analysis would indicate there is:

**1 chance in a 1000 of making $1,999,960,000 or**
**1 chance in a 1000 of making about $2 billion**
**But 999 times out of a thousand we'd lose $40,000**

Recognize this analysis indicates a very different Risk Reward game.

## Fire, Ready, Aim

Some of the management gurus are telling us that the **speed** on the decision is more important than the quality of the decision. We believe there is a need for balance between speed and quality. The possible benefits and consequences of each decision will help us determine which factor is more important. Decision Analysis is a great way to increase the speed of the decision making process. Since you have thought about and created a strategy of how you will behave **before** you actually face the decision, you are able to act quickly.

## Possible Major Flaw In Our Analysis

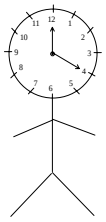
The criteria of always selecting the alternative that maximizes the expected profit has a possible major flaw. The idea of using the reasoned out average assumes a situation where it is appropriate to assume the **Law of Large Numbers** will "work."

For our problem we might assume that this company is constantly developing new products and must decide whether to sell the rights or to produce and market. It then makes sense to use the idea of Expectation, the Reasoned Out Average, as over **time.**

**Our Observed Average Profits Will Approach Our Reasoned Out Average Profits, assuming our reasoning is correct.**

But how much **time** will it take to see our observations approaching our expectations. The scenario that we painted with the huge payoff, $2 billion, has a potentially very long **time** frame before one would experience success.

**Our Frame on Time Will Be More and More Important**



Wall Street has put tremendous pressure on companies to show consistent quarterly profits. Wall Street does not like surprises; small negative downturns from projected profits has caused the market to react swiftly and without logic. Repeating the old adage that says:

**The Market Rises On Emotion and Falls on Facts**

In today's market environment do companies have time to let the Law of Large Numbers work?

**What is Best in the Short Term is often Not Best for the Long Term**
**Remember, Deming's Deadly Disease of Worship of Quarterly Dividends**

## Opportunity Costs

Another factor that would have to be considered with this decision is what opportunities do we have if we immediately sell the patent and have $1.5 million to invest. Time value of money would be added to our analysis. The $1.96 million would be the average amount we earn after 1 year, this strategy involves an immediate investment of $1 million. What opportunities are we passing up by investing our $1 million. We leave the discussion of opportunity costs and time value of money to the economists and finance people.

**Summary**
The Decision Analysis Process is just common sense:
**Step 1** Recognize the **rules** of the **game**.
**Step 2** **Plan** how to intelligently play the game **before** you get into the game.
**Step 3** **Understand** what **could happen** and how often it could by following this plan.

## Sensitivity Analysis

There is a fourth step to the Decision Analysis process that is called **sensitivity analysis**.
The strategy that we have determined is completely based on the "quality" of the numbers we analyzed. For the decision just studied all the numbers on cost, royalties, sales, probabilities etc. were estimates. What if these estimates are wrong?

Sensitivity analysis studies the question: How sensitivity is our strategy to changes in the numbers. If the estimated sales numbers or probabilities for these sales are changed by a "small" amount and we redo our analysis do we get a different strategy? If the answer is yes, we would have less faith in our strategy.

Ideally our strategy does not change to changes in the numbers used. When this happens we say the strategy is insensitive (stays the same) to the changes in the "numbers." This is a way of trying to determine how **confident** we should be of our **strategy**. We study this in Chapter 11.

**Reflecting** Do you have a formal or informal way of handling business decisions? Personal decisions?

1. List and discuss at least three concepts that you have learned that will influence your thinking.

2. List and discuss at least three concepts that you wish to or need to further think about. Discuss how you plan to continue to study these concepts.