Decision Analysis

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Quotes on Decision Making

In any moment of decision, the best thing you can do is the right thing, the next best thing is the wrong thing, and the worst thing you can do is nothing. Theodore Roosevelt

A good decision is based on knowledge and not on numbers. Plato

There is no decision that we can make that doesn't come with some sort of balance or sacrifice. Simon Sinek

Quotes on Decision Making

Some of our important choices have a time line. If we delay a decision, the opportunity is gone forever. Sometimes our doubts keep us from making a choice that involves change. Thus an opportunity may be missed.
James E. Faust

I don't think leadership demands 'yes' or 'no' answers; I think leadership is providing the forum for making the right decision, which doesn't demand unanimity.
Arthur Ochs Sulzberger, Jr.

Decision Analysis

Decision analysis is defined as the process and methodology of identifying, modeling, assessing and determining an appropriate course of action for a given decision problem.

This process often involves a wide array of tools and the basic approach is generally to break the problem down into manageable and understandable parts that the decision maker can comprehend and handle.

Decision Analysis

When analyzing the decision-making process, the context or environment of the decision to be made allows for a categorization of the decisions based on the nature of the problem or the nature of the data or both.

There are two broad categories of decision problems:

- Decision making under certainty
- Decision making under uncertainty.

Decision Analysis

Decision making under certainty means that the data are known deterministically or at least at an estimated level the decision maker is comfortable with in terms of variation.

The decision alternatives can be well defined and modeled.

The techniques used for these problem types are many and include:

- Linear programming
- Nonlinear programming
- Integer programming
- Multi-objective optimization
- Goal programming
- Analytic hierarchy process, and others.

Decision Analysis

Decision making under risk means that there is uncertainty in the data, but this uncertainty can be modeled probabilistically.

Note there are some that do not use this designation since they believe all probability is subjective, hence all decisions not known with certainty are uncertain. However, we will use the common convention of referring to probabilistic models as decision making under risk.

Decision making under uncertainty means the data can not be modeled probabilistically and are imprecise or vague.

Terminology

Decision Maker: the entity responsible for making the decision. This may be a single person, a committee, company, etc.

Alternatives: A finite number of possible decision alternatives or courses of action available to the decision maker. The decision maker generally has control over the specification and description of the alternatives.

Terminology

States of Nature: The scenarios or states of the environment that may occur but are not under control of the decision maker.

Outcome. Outcomes are the measures of net benefit, or payoff, received by the decision maker. This payoff is the result of the decision and the state of nature.

Investment Example

Assume you have $10,000 to invest and are trying to decide between a speculative stock (one that has high risk, but can generate substantial returns), a conservative stock (one that will perform well in any environment, but doesn't have the potential for large returns), bonds, and certificates of deposit.

Investment Example

Note that for each combination of decision alternative and state of nature there is a corresponding payoff. The payoff in this example is the expected rate of return.

Payoff Matrix for Investment Problem

	State of Nature		
Alternative	> 5%	3-4%	0-2%
SS	18%	14%	-5%
CS	13%	10%	5%
B	10%	6%	4%
CD	7%	3%	1%

Decision Making Under Risk

One way to deal with the uncertainty is to make the uncertain more certain. This can be done by using probability to represent the uncertainty. That is, uncontrollable factors are modeled and estimated probabilistically. When this is possible, the uncertainty is characterized by a probability distribution.

Decision Making Under Risk

In the given investment example, assume that a probability distribution for the possible states of nature can be determined based on the past data related to economic growth. These prior probabilities are given in the table

	State of Nature		
Alternative	> 5%	3-4%	0-2%
SS	18%	14%	-5%
CS	13%	10%	5%
B	10%	6%	4%
CD	7%	3%	1%
Prior Probability	0.1	0.6	0.3

Decision Making Under Risk

Maximum Likelihood

The idea behind maximum likelihood is that good things always happen. That is choose the best outcome.

To find the best choice, first find the state of nature with the largest probability of occurring and then choose the alternative for that state of nature with the maximum payoff.

In the investment example given in the table, the state of nature with the largest probability is 3-4% growth. For that state of nature, the speculative stock has the largest rate of return. Therefore, based on this criterion the decision would be to invest in speculative stock.

Decision Making Under Risk

Expected Value Under Uncertainty

For a more balanced approach, a decision maker can assume that the prior probabilities give an accurate representation of the chance of occurrence. Therefore, instead of being overly optimistic the decision maker can compute the expected value for each alternative over the states of nature and then choose based on those expected values.

Decision Making Under Risk

Expected Value Under Uncertainty

From the table, for the alternative SS, the expected value would be 0.1×18% + 0.6×14% + 0.3×(-5%) = 8.7%. The expected value for each alternative is given in the table below.

Expected Values of Each Alternative

	State of Nature			
Alternative	> 5%	3-4%	0-2%	Expected Value
SS	18%	14%	-5%	8.70%
CS	13%	10%	5%	8.80%
B	10%	6%	4%	5.80%
CD	7%	3%	1%	2.80%
Prior Probability	0.1	0.6	0.3	

Based on expected value the best decision would be to invest in conservative stock.

Decision Making Under Risk

Expected Opportunity Loss - EOL

To avoid the possibility of having missed a large opportunity, expected opportunity loss (EOL) looks to minimize the opportunity loss or regret. To do this, the possible opportunity loss for each state of nature is determined for each alternative. This is done by taking the largest payoff value in each column (state of nature) and then for each alternative subtracting the payoff for that alternative from the largest payoff in the column.

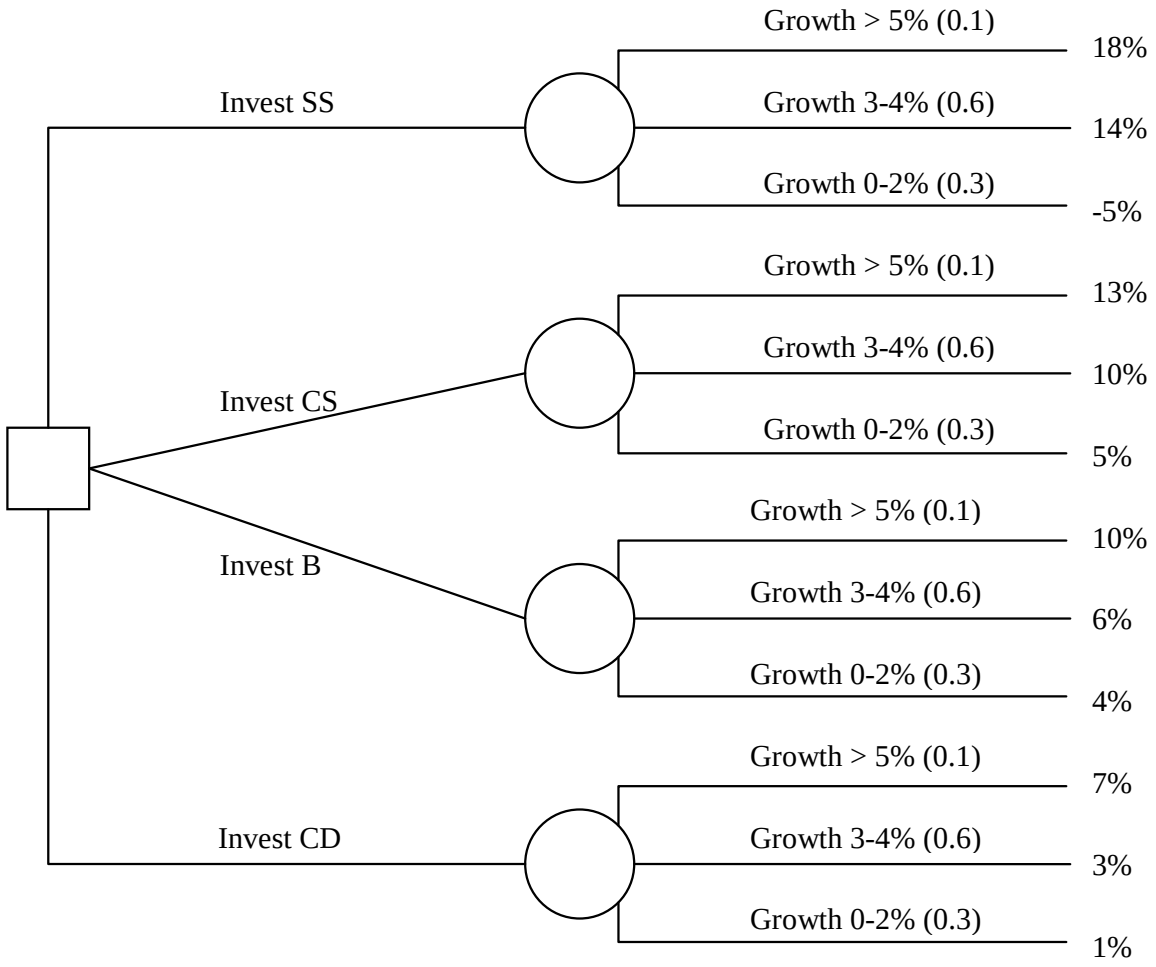
Decision Making Under Risk

For our example, the opportunity loss is computed for each alternative and state of nature in the table. Once the opportunity losses are known, the expected opportunity loss is determined for each alternative (row) by using the prior probabilities. For example, in the table the expected opportunity loss for alternative CS is given by 0.1×5% + 0.6×4% + 0.3×0% = 2.9%.

	State of Nature			
Alternative	> 5%	3-4%	0-2%	EOL
SS	18-18= 0%	14-14=0%	5-(-5)=10%	3%
CS	18-13=5%	14-10=4%	5-5=0%	2.9%
B	18-10=8%	14-6=8%	5-4=1%	5.9%
CD	18-7=11%	14-3=11%	5-1=4%	8.9%
Prior Probability	0.1	0.6	0.3	

Decision Trees

Note that each square node denotes the alternative chosen and each circular node represents the state of nature and the numbers at the end of each decision path (lines) are the payoffs for that course of action.



Decision Making Under Uncertainty

When it is not possible to find a probability distribution for a decision problem, or none exists, that problem is said to be uncertain. In this situation, it is not possible to determine expected values and one must find other factors on which to make a decision. The payoff matrix is still employed for problems under uncertainty, but without any prior probabilities.

Decision Making Under Uncertainty

A local food processing plant has developed a low calorie snack that has taken the market by storm. After only being on the market for three months sales have outpaced forecasts by more than 60% and the plant cannot meet demand.

After several different surveys it was found that sales could hold steady, increase by an additional 20%, increase by an additional 60% or decrease by 10%, but marketing cannot give a distribution for the possible outcomes.

Decision Making Under Uncertainty

After researching possible solutions the following alternatives have been put forth by the engineering team:

A1) Build an additional plant that would be able to increase the total production of the product by 120%,
A2) Add an identical additional line to the current plant that would increase production by 30%,
A3) Expand the current plant and replace current line with new technologies that would allow total production to increase by 60% and
A4) Hire a full time operations analyst to increase efficiency with an estimated increase in production of 15%.

Decision Making Under Uncertainty

An economic analysis of each alternative has been carried out and the net profit gained from increased sales minus implementation costs is used as the payoff for the alternative. The table below gives the payoff matrix and the values are in $1,000.

	State of Nature			
Alternative	Decrease 10%	Steady	Increase 20%	Increase 60%
A1	-1,500	-400	1,100	2,150
A2	-450	200	500	500
A3	-850	-75	450	1,100
A4	-200	300	300	300

Decision Making Under Uncertainty

Maximin (Minimax) Criterion

This criterion is a conservative approach to managing the unknown risk. The intent is to determine the worst that can happen with each alternative and then pick the alternative that gives the best worst result. Implementation of this criterion is quite simple. For maximin, identify the minimum in each row and then select the alternative with the largest row minimum.

	State of Nature				
Alternative	Decrease 10%	Steady	Increase 20%	Increase 60%	Row Minimum
A1	-1,500	-400	1,100	2,150	-1,500
A2	-450	200	500	500	-450
A3	-850	-75	450	1,100	-850
A4	-200	300	300	300	-200*

Decision Making Under Uncertainty

Maximax (Minimin) Criterion

This criterion is the opposite of maximin in that it is very optimistic and risk-seeking. For this approach it is assumed that the best scenario possible will happen. Therefore, for each row the maximum is chosen and then the alternative with the maximum row maximum is selected.

	State of Nature				
Alternative	Decrease 10%	Steady	Increase 20%	Increase 60%	Row Maximum
A1	-1,500	-400	1,100	2,150	2,150*
A2	-450	200	500	500	500
A3	-850	-75	450	1,100	1,100
A4	-200	300	300	300	300

Decision Making Under Uncertainty

Hurwicz Criterion

This criterion is designed to mitigate the extremes and to allow for a range of attitudes of the decision maker. The basis of this approach is an index of optimism given by α, such that $0 \leq \alpha \leq 1$. The more certain a decision maker is that the better states of nature will occur the larger the value of α, the less certain the smaller the value of α.

Laplace Criterion or Expected Value

The Laplace criterion is another more optimistic approach to the problem. The basis of this approach is that since the probabilities are not known for the states of nature and there is no reason to think otherwise, each state of nature should be viewed as equally likely.

Minimax Regret (Savage Regret)

The last approach is based on the concept of regret discussed previously. The idea is to not look at payoffs, but instead at lost opportunities (regret). The regret is based on each state of nature and is determined by looking at the best outcome of that state against the other possible outcomes.

Practical Decision Making

- “A good solution to a well-posed decision problem is always better than an excellent solution to a poorly posed one”
- Focus on what’s important.
- Logical and consistent.
- Subjective and objective.
- Gather information to form an opinion.
- Straightforward, reliable, flexible.

- Problem
  - Work on the right decision problem.
    - The way you frame your decision at the outset can make all the difference. To choose well, you need to state your decision problems carefully, acknowledging their complexity and avoiding unwarranted assumptions and option-limiting prejudices.
- Objectives
  - Specify our objectives.
    - Your decision should get you where you want to go. Ask yourself what you most want to accomplish and which of your interests, values, concerns, fears, and aspirations are most relevant to achieving your goal. Thinking through your objectives will give direction to your decision making.

- Alternatives
  - Create imaginative alternatives
    - Assessing frankly the consequences of each alternative will help you to identify those that best meet your objectives all your objectives
- Consequences
  - Understand the consequences
    - Understand and assess the possible affects and outcomes associated with each particular alternative you explore. Weigh the pros and cons of the consequences of each possible choice.
- Tradeoffs
  - Grapple with your tradeoffs
    - Important decisions usually have conflicting objectives - and therefore you have to make tradeoffs. You need to give up something on one objective to achieve more in terms of another.

- Uncertainty
  - Acknowledge and measure the existence of uncertainties
    - The first step is to acknowledge the existence of the uncertainties. Then you need to think them through systematically, understanding the various outcomes that might unfold, their likelihoods, and their impacts.
- Risk Tolerance
  - Understand your willingness to take risks
    - Your risk tolerance expresses your willingness to take risk in your quest for better consequences. The more desirable the better consequences of a risk profile relative to the poorer consequences, the more willing you will be to take the risks necessary to get them.
- Linked Decisions
  - How will this decision affect other decisions in the future?
    - Many important decision problems require you to select now among alternatives that will greatly influence your decisions in the future.

The Problem is?

- Define the problem –
- Is it a problem or an opportunity?
- What are the constraints and can any be avoided or eliminated?

What are your Objectives?

- Help Determine What Information to Seek
- Help Explain Your Choices to Others
- Step 1: Write Down All Concerns
- Step 2: Convert Concerns Into Succinct Objectives
- Step 3: Separate Ends From Means/Establish Fundamental Objectives
- Step 4: Clarify Objective Meaning

Alternatives?

- What are your alternatives to consider in terms of the problem and the consequences?
- You want to challenge constraints, keep an independent mind, learn from what has happened before
- Realize a perfect solution doesn't exist. You hope to get as much satisfaction as possible

Consequences

- Be sure to really understand the consequences of possible solutions. If you do not, you surely will afterwards, and you may not be very happy with them
- Mentally put yourself in the future
- Create a description of the consequences for each alternative
- Eliminate any clearly inferior alternatives
- Organize descriptions of remaining alternatives into a consequence table

How Much Risk Can You Take

- Risk tolerance expresses willingness to take risk in order to find better outcomes
- Most people are risk averse, the poorer consequences will weigh more heavily on your mind
- Assign desirability scores to all consequences.
- Calculate each consequence's contribution to the overall desirability of the alternative
- Calculate each alternative's overall desirability score
- Compare the overall desirability scores associated with the alternatives and choose

Pitfalls to Consider

- Don't over focus on the negative
- Don't fudge the probabilities to account for risk
- Don't ignore significant uncertainty
- Avoid foolish optimism
- Don't avoid making risky decisions because they are complex

Traps to Avoid

- The Anchoring Trap - Disproportionate weight to initial information
- Status Quo Trap – Do what has been done to avoid decisions
- The Confirming Evidence Trap - Seek Out Supporting Evidence - Ignore Opposing Evidence
- The Prudence Trap - Err on the Side of Caution
- Can we build tests to help us avoid traps?

Linked Decisions

- What we decide now will also impact future decisions. Must think about what we might need to decide to do in the future.
- This is why we need to view this as an experiment and make our decisions and adjust accordingly in the future
- Key is that our decisions or not set in stone and can be changed when more information presents itself

Summary

The following basic systems approach to decision making summarizes this approach.

1. Address the right decision problem
2. Clarify your real objectives and recognize means and ends
3. Develop a range of creative alternatives
4. Understand the consequences of the decisions (short and long term)
5. Make appropriate tradeoffs between conflicting objectives

Summary

6. Deal appropriately with uncertainties

7. If there are multiple objectives, make appropriate tradeoffs

8. Take account of your risk attitude

9. Plan ahead for decisions linked over time

10. Make your decision, analyze possible other solutions through the use of different methodologies, and perform sensitivity analysis