Decision Analytics

Problem Solving

- The process of identifying a difference between the actual and desired state of affairs and then taking action to resolve the difference.
- It involves the following seven steps:
  - Identify and define the problem
  - Determine the set of alternative solutions
  - Determine the criterion or criteria that will be used to evaluate the alternatives.
  - Evaluate the alternatives
  - Choose an alternative
  - Implement the selected alternative.
  - Evaluate the results to determine whether a satisfactory solution has been obtained.

Decision Making

- The term generally associated with the first five steps of the problem solving process.
- The first step of decision making is identify and define the problem.
  - Single-criterion decision problems
  - Multicriteria decision problems
- Decision making ends with the choosing of an alternative, which is the act of making decision.

Example

- Step 1: An unemployed youth who would like a position that will lead to a satisfying career.
- Step 2: The set of alternative solutions
  - Accept the position in Bangalore
  - Accept the position in Hyderabad
  - Accept the position in Noida
  - Accept the position in Mumbai
- Step 3: Determine criterion or criteria to evaluate the four alternatives
  - Single criterion decision problem: Starting salary
  - Multi criteria decision problem: Starting salary, potential for advancement, and location

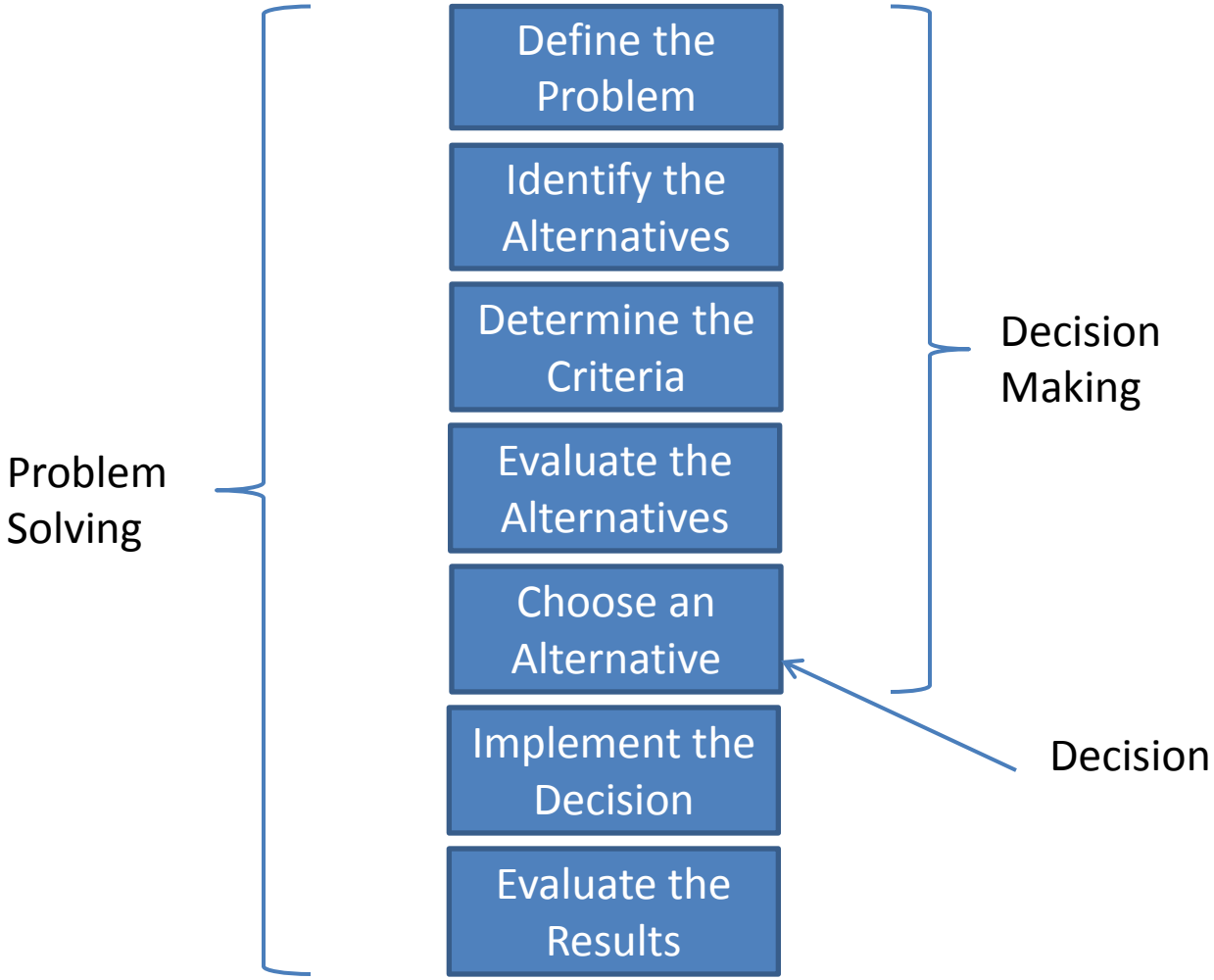
Example…contd

- Step 4: Evaluate each of the alternative with respect to each criteria

Alternative	Starting Salary	Potential for Advancement	Job Location
Bangalore	Rs 38,500	Average	Average
Hyderabad	Rs 36,000	Excellent	Good
Noida	Rs 36,000	Good	Excellent
Mumbai	Rs 37,000	Average	Good

- Step 5: Select alternative 3. The alternative 3 is referred to as the *decision*.

Problem Solving and Decision Making



Decision Analysis

- To determine optimal strategies in situation involving several decision alternatives and an uncertain or risk-filled pattern of events.
- It is the study of how people take decisions as well as collection of techniques to support decision choices.
- They consider individual's preferences and attitude towards risk. The decision process is modeled.

Decision Problem

- Many decisions involve a choice from among a small set of alternatives with uncertain consequences.
- Such decision problems are formulated by defining three things
  - The **decision alternatives** that can be chosen.
  - The **uncertain events** that may occur after a decision is made along with their possible **outcomes**.
  - The consequences associated with each decision and outcome, which are usually expressed as **payoffs**.

Uncertain Events and Outcomes

- The outcomes associated with uncertain events are defined so that one and only one of them will occur.
- They may be quantitative or qualitative
- Example: size of new factory
  - Uncertain event: future demand for the product
  - Outcomes: sales unit, dollars
- Example: vacation planning
  - Uncertain event: weather
  - Outcomes: sunny and warm, sunny and cold, rainy and warm, rainy and cold an so on.

Payoff

- It is a measure of the value of making a decision and having a particular outcome occur.
- This might be a simple estimate made judgementally or a value computed from a complex spreadsheet model.
- Payoff table is a matrix whose rows correspond to decisions, columns correspond to events and cell value is payoff.
- The decision maker first selects a decision alternative, after which one of the outcomes of the uncertain event occurs, resulting in the payoff.

Selecting a Mortgage Instrument

Many young families face the decision of choosing a mortgage instrument. Suppose the Durr family is considering purchasing a new home and would like to finance $150,000. Three mortgage options are available, a 1-year adjusted rate mortgage (ARM) at a low interest rate, a 3-year ARM at a slightly higher rate and a 30 year fixed mortgage at the highest rate. However, both ARMs are sensitive to interest rate changes and the rates may change resulting in either higher or lower interest charges. Thus the potential changes interest rates are the uncertain outcomes. Because the family anticipates staying in the home for atleast 5 years, they want to know the total interest costs they might incur. These represent the payoffs associated with their choice and the future change in interest rates.

Example

Decision/Outcome	Rates Rise	Rates Stable	Rates Fall
1-year ARM	61,134	46,443	40,161
3-year ARM	56,901	51,075	46,721
30-year fixed	54,658	54,658	54,658

Decision Strategies without Outcome Probabilities

- There are quantitative approaches that model different risk behaviours for making decisions that involve uncertainty.
  - Decision Strategies for a Minimize Objective
  - Decision Strategies for a Maximize Objective
- Aggressive, Conservative and Opportunity loss strategies can be applied for max and min payoff.

Aggressive (Optimistic) Strategy

- To seek the option that holds the promise of minimizing the potential loss.
- What is the best that could result from each decision? Choose the decision that corresponds to the best of the best. Also called a minimin strategy.
- Choose the decision that minimizes the minimum payoff that can occur among all outcomes for each decision.

Example

Find the best payoff that is the lowest cost outcome for each decision:

Decision/ Outcome	**Rates Rise**	**Rates Stable**	**Rates Fall**	**Best Payoff**
1-year ARM	61,134	46,443	40,161	40,161
3-year ARM	56,901	51,075	46,721	46,721
30-year fixed	54,658	54,658	54,658	54,658

Conservative (Pessimistic) Strategy

- To take a more pessimistic attitude file choosing the option.
- What is the worst thing that might result from my decision? Then select the decision that represents the best of the worst.
- It is also known as minimax strategy.
- The decision that minimizes the largest payoff that can occur among all outcomes for each decision.

Example

Find the worst payoff that is the largest cost outcome for each option:

Decision/ Outcome	**Rates Rise**	**Rates Stable**	**Rates Fall**	**Worst Payoff**
1-year ARM	61,134	46,443	40,161	61,134
3-year ARM	56,901	51,075	46,721	56,901
30-year fixed	54,658	54,658	54,658	54,658

Opportunity Loss Strategy

- The “regret” that people often feel after making a non optimal decision.
- It is the absolute difference between the best decision for that particular outcome and the payoff for the decision that was chosen.
- The conservative strategy is applied on opportunity loss values.
- Also called minimax regret strategy.

Example

Find the worst payoff that is the largest cost outcome for each option:

Decision/ Outcome	**Rates Rise**	**Rates Stable**	**Rates Fall**	**Max Opportunity Loss**
1-year ARM	6,476	--	--	6,476
3-year ARM	2,243	4,632	6,560	6,560
30-year fixed	--	8,215	14,497	14,497

Maximize Objective: Aggressive Strategy

- The best payoff for each decision would be the largest value among all outcomes. Then choose the decision corresponding to the largest of these.
- Also called as maximax strategy or “Risk seeking” strategy

Decision/ Outcome	**Rates Rise**	**Rates Stable**	**Rates Fall**	**Best Payoff**
1-year ARM	61,134	46,443	40,161	61,134
3-year ARM	56,901	51,075	46,721	56,901
30-year fixed	54,658	54,658	54,658	54,658

Maximize Objective: Conservative Strategy

- The worst payoff for each decision would be the smallest value among all outcomes. Then choose the decision corresponding to the largest of these.
- Also called as maximin strategy or “Risk averse” strategy

Decision/ Outcome	Rates Rise	Rates Stable	Rates Fall	Worst Payoff
1-year ARM	61,134	46,443	40,161	40,161
3-year ARM	56,901	51,075	46,721	46,721
30-year fixed	54,658	54,658	54,658	54,658

Maximize Objective: Opportunity Loss Strategy

- It is the absolute difference between the largest value for that particular outcome and the payoff for the decision that was chosen.
- Choose the decision that minimizes the maximum opportunity.

Decision/ Outcome	**Rates Rise**	**Rates Stable**	**Rates Fall**	**Max Opportunity Loss**
1-year ARM	--	8,215	14,497	14,497
3-year ARM	4,233	3,583	7,937	3,583
30-year fixed	6476	--	--	6,476

Conflicting Objective

- Many decisions require some type of tradeoff among conflicting objectives.
  - Risk vs reward
  - Cost vs customer satisfaction
- A simple decision rule: Maximize the ratio of good objective to the bad.
- Plot good objective on x axis and bad objective on y axis.
- Then graph the tangent line to the tradeoff curve that goes through the origin.
- The point at which the tangent line touches the curve represents the best return to risk tradeoff.
- Other techniques: scoring models, goal programming and analytic hierarchy process (AHP).

Decision Strategies with Outcome Probabilities

- The aggressive, conservative, and opportunity-loss strategies assume no knowledge of the probabilities associated with future outcomes.
  - Average Payoff Strategy
  - Expected Value Strategy
  - Evaluating Risk

Average Payoff Strategy

- Principle of insufficient reason: if there is no reason for one outcome to be more likely than another, treat them as equally likely.
- In this strategy, evaluate each decision by averaging the payoff. Then select the decision with the best average payoff.

Decision/ Outcome	**Rates Rise**	**Rates Stable**	**Rates Fall**	**Average Payoff**
1-year ARM	61,134	46,443	40,161	49,246
3-year ARM	56,901	51,075	46,721	51,566
30-year fixed	54,658	54,658	54,658	54,658

Expected Value Strategy

- Expected Value Strategy is applied when the probabilities of the outcomes are not all the same.

Decision/ Outcome	**Rates Rise 0.6**	**Rates Stable 0.3**	**Rates Fall 0.1**	**Average Payoff**
1-year ARM	61,134	46,443	40,161	54,629.40
3-year ARM	56,901	51,075	46,721	54,135.20
30-year fixed	54,658	54,658	54,658	54,658.00

Evaluating Risk

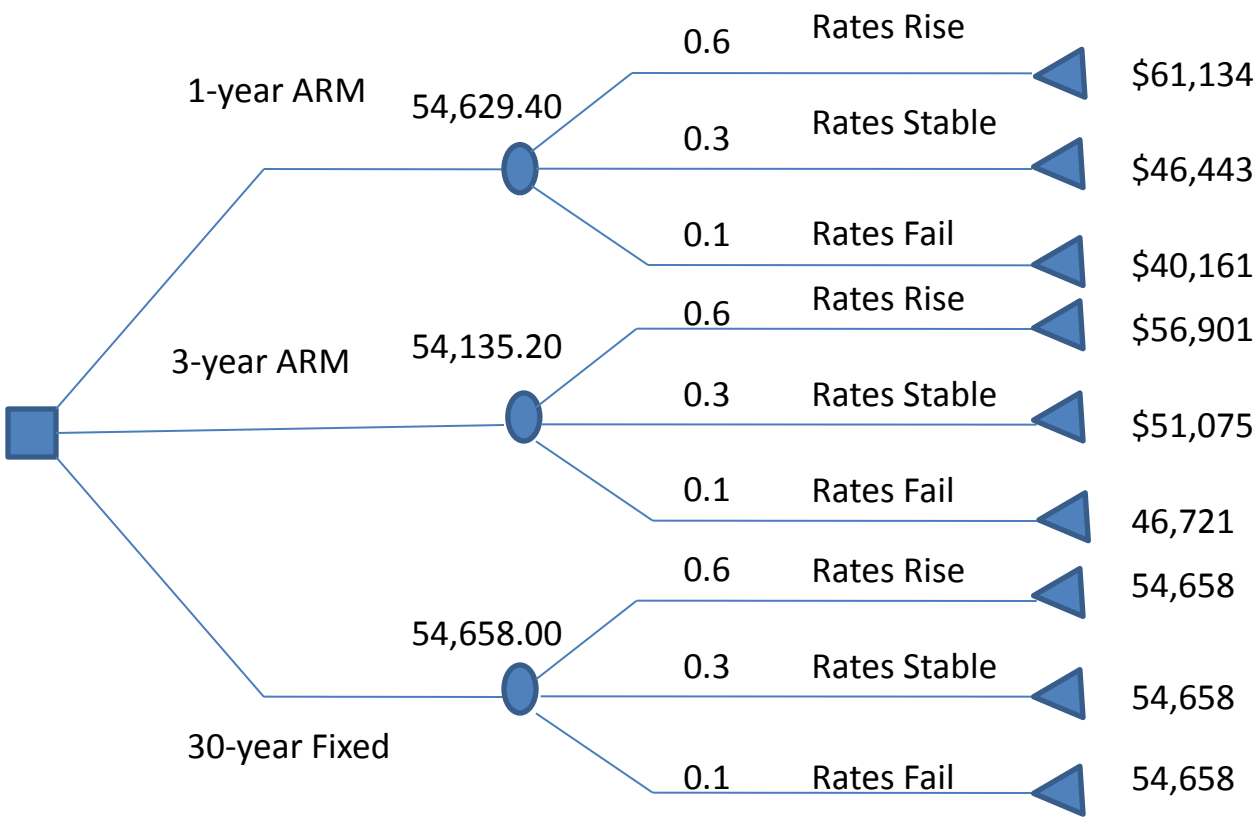
- For one time decision, the expected outcome will never occur.
- Hence we need to weigh the risk associated with the decision.
- Compute the standard deviation of the outcome associated with each decision.

Decision	Standard Deviation	Risk
1-year ARM	10,763.80	High
3-year ARM	5107.71	Moderate
30-year fixed	--	No

Decision Tree

- A graphical model to structure a decision problem involving uncertainty.
- It consists of a set of nodes and branches.
- Decision node: a selection of a decision from among several alternatives. They are expressed by square.
- Event node: an outcome over which the decision maker has no control. They are represented by a circle.
- Outcomes are the payoffs that occur due to specific sequences of decisions and events. It is represented by traingle.
- Branches are associated with decisions and events.

Example


1-year ARM
54,629.40
0.6
Rates Rise
$61,134
0.3
Rates Stable
$46,443
0.1
Rates Fail
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