Managerial Decision Making

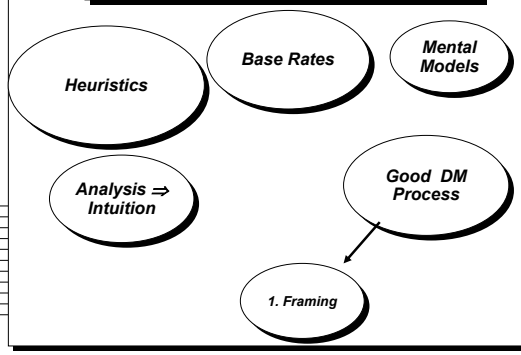
Session 3

Rationality and Probability in Decision Making

Course Business

- **Writing Assignments:**
  - **Turn in Writing Assignments at the end of class on Tuesdays.**
  - **You should write at least one of the Writing Options for Week 2 or Week 3. So . . . tonight or next week . . .**
- **Web-based Surveys**
  - **for Week #3, it will be an XLS spreadsheet this time . . more on it tomorrow**
  - **They should be ready for you on Wednesday AM**
  - **Take it by Sunday night**

MDM: Key Concepts so far



Assumptions re: Decision Making

- People are "rational"
  - **We need a definition of "rational"**
- **rational (răsh'e-năl) – Consistent with or based on reason; logical**

4 Criteria for Rational Choice

1. **Based on the decision maker's current "assets".**
   - **Not only money, but physiological state and capacities, social relationships and feelings**
2. **Based on all the possible consequences of the choice**
3. **Uncertainties are evaluated according to the basic rules of probability – *Using probability correctly***
4. **It is adaptive within the constraints of probabilities and the values associated with each of the the consequences of the choice – *Maximizing expected utility***

What are the odds?

Never bought a lottery ticket?

…you'll still have to face *PROBABILITIES…ALL THE TIME*

Probability judgments

- What are the odds of…?

-snow yesterday? (in Hanover, almost April)

-The Democrats winning the next Presidential election?

-S&P500 having a positive return in 2003?

-How Do We Develop?

-Frequency Data/Base Rates

-Subjective Assessment Probabilities

Axioms of Probability Theory

- For any event A (e.g. will it rain tomorrow?):

$$0 \leq Pr(A) \leq 1$$

- It follows that the probability of A not happening is:

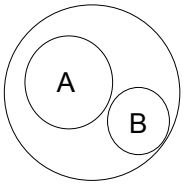
$$1 - Pr(A)$$

- If the set of events of a given type is exhaustive and denoted by S

then $Pr(S) = 1$

Axioms of Probability Theory

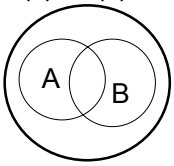
- If A and B are mutually exclusive, then
  Pr (A or B) = Pr (A) + Pr (B)



- Example: What is the probability of rolling either a 2 or a 4 with a single die?

Axioms of Probability Theory

- Addition Rule (if NOT mutually exclusive):
  Pr (A or B) =Pr (A)+ Pr (B) – Pr(A&B)



- Example: What is the probability that a roll of a die is even or a prime number?
  - Pr [(2,4,6) or (2,3,5)]

Independent Events

- Two events are independent when the occurrence of one does not influence the probability of the occurrence of the other.
- Independence Example: rolling two dice, the number on the first roll does not affect the answer on the second
- Non-independence Example (rolling two dice sequentially):
  - Event A: getting a two on roll of first die
  - Event B: getting sum of 9 when rolling two dice

List?

Axioms of Probability Theory

- Multiplication Rule when Independent:

  Pr (A & B) = Pr (A)* Pr (B)

- Example (two dice, first roll & second roll):
  - $Pr(Five_1 \ \& \ Six_2) = 1/6 * 1/6 = 1/36$
  - Same as $Pr(Four_1 \ \& \ Four_2)$
- Pr(Yankees in World Series) = .2
  Pr(Boston in World Series) = .1
- Pr (Yanks & Boston) = .2 * .1 = .02 ?

Should you be shocked?

On the first anniversary of the terrorist attack, the evening numbers drawn in the New York Lottery were 9-1-1.

What is the probability of that?

The multiplication rule. . .

What factors mentioned in "The Odds of That" help explain your first reaction?

Conditional Probability

- **Conditional Probability:**
  Pr(A|B) is the probability of A <u>given that</u> B occurred or will occur
- **Now, if A & B are independent, then:**

  Pr (A | B) = Pr (A)
- **<u>Example</u>: Pr(being dealt an Ace)**
  - **Pr (Ace | if it's first card dealt) = 1/13 but**
  - **Pr (Ace | if it's second card dealt) ≠ 1/13**

Axioms of Probability Theory

- **<u>Multiplication Rule when NOT Independent</u>:**

  Pr (A & B) = Pr (A) * Pr (B|A)
- **Pr (Yanks & Boston) =**
  Pr (Yanks) * Pr (Boston|Yanks)
- **But we KNOW Pr (Boston|Yanks) = 0!!!!!**
- **MORE ON THIS IDEA TOMORROW . . .**

Maximizing Expected Utility

Roger's got a problem. . .

Roger has forgotten whether it is his wife Christine's birthday or sometime else this week. Should he buy her a bunch of flowers to give her when he arrives home?*

<u>His best friend's advice</u>:

". . . Since you are completely clueless about when your wife's birthday is, we can assign a 50%-50% chance to the "birthday today" and "not birthday" cases. . . Hence you should be indifferent."

**this example is from Taking Chances: winning with probability by J. Haigh*

Should Roger be indifferent?

- **Let's assume a 50-50 uncertainty sounds reasonable**
- **…but Roger does have big concerns on Christine's reactions:**
  - She is ***neutral*** if she gets no flowers on a regular (non-birthday) day (utility = 0), although flowers will generally make women happy (+1)
  - She will be ***happy*** if Roger brings her flowers on her birthday, which shows her husband's memory works OK sometimes (+2)
  - She will be ***extremely unhappy*** if he forgets her birthday, and this could be very serious for Roger (-5).
  - Buying flowers cost Roger the equivalent of –1 util.

Should Roger be indifferent?

	Not birthday	Birthday
No flowers	0	-5
Flowers	1	2

The expected utility of "no flowers"

= (50% * 0) + (50% * -5) – 0 = -2.5

The expected utility of "flowers"

= (50%* 1) + (50% * 2) - 1 = 0.5 ***Always take flowers!***

Expected Utility Theory

- **Expected Value (of a decision or gamble) =**

$$\sum \text{Probability of each outcome} * \text{Value of each outcome}$$
$$= 50\% * \text{gain of } \$100 \; + \; 50\% * \text{loss of } \$100 = EV = 0$$

- **But the Expected Utility (of a decision or gamble) =**

$$\sum \text{Probability of each outcome} * \text{Utility of each outcome}$$
$$= 50\% * (\text{Utility of } +\$100) \; + \; 50\% * (\text{Utility of } -\$100) = ???$$

- ***How and why is this difference important?***
  - ***I may not value gains and losses equally . . .***
  - ***Usually individuals are RISK AVERSE***

Axioms of Expected Utility

- **Can Rank Order** all choices: either > , < , or =
- **Stochastic Dominance**: If A is preferred or equal to B in every aspect, then it must be chosen over B
- **Cancellation**: Decisions should only differ based on what is different about A and B, not what is the same
- **Transitivity**: if A > B and B > C, then A > C
- **Frame Invariance**: if I "frame" a problem differently, but the outcomes are exactly the same, you should always make the same decision, if you are rational

Problems with Expected Utility

		DIMENSIONS	
		Intelligence (IQ)	Experience, Years
APPLICANTS	A	120	1
	B	110	2
	C	100	3

- **Decision Rule**: If Applicant A is not more than 10 IQ points smarter than others, choose the one with more experience
  - Is this a problem in a world where people are maximizing Expected Utility?

Violates Transitivity!

Problems with Expected Utility

- ***Do you get headaches frequently, and if so, how often?***
- **Mean answer: 2.2 per week**
- ***Do you get headaches occasionally, and if so, how often?***
- **Mean answer: 0.7 per week**

Violates Frame Invariance!

Source: Plous (1994)

Problems with Expected Utility

- **You have just won $30. Now choose between:**
  - **A. a 50% chance to win $9 and a 50% chance to lose $9**
  - **B. No further bets**
- **30% choose B**
- **Choose between:**
  - **A*. A 50% chance to win $39 and a 50% chance to win $21**
  - **B. A sure gain of $30**
- **57% choose B***

Violates Frame Invariance!

Problems with Expected Utility

- **Question A. A shortage has developed for a popular model of car, and customers must now wait two months for delivery. A dealer has been selling these cars at list price. Now the dealer prices this model at $200 above list price.**
  - **N=130 29% say Acceptable 71% say Unfair**
- **Question B. A shortage has developed for a popular model of car, and customers must now wait two months for delivery. A dealer has been selling these cars at a discount of $200 below list price. Now the dealer sells this model only at list price**
  - **N=123 58% say Acceptable 42% say Unfair**

Violates Frame Invariance!

Problems with Expected Utility A Managerial Example

The Base case:

Assume you are the vice president of manufacturing in a Fortune 500 company that employs over 130,000 people with annual sales exceeding $10 billion. Due to a recession and structural changes in your industry, one of your factories (with 600 hundred employees) is faced with either a complete or partial shutdown. You and your staff have carefully narrowed the options to the following two, which financially are equally attractive. Now your choice will be mainly based on the effect of the decision on the plant workers, who have stood by the company for many hard years without unionizing.

Assuming 1) and 2) are the ONLY alternatives, which option would you choose?

From *Wharton on Making Decisions*

Problems with Expected Utility A Managerial Example (Cont.)

- If *Expected Value* is your only concern, what would be your choice?
  - You should be indifferent!
- In fact you, (implicitly or explicitly) thought about *Expected Utility*.
  - So you do have a preference. . .

Problems with Expected Utility A Managerial Example (Cont.)

Half of you were given Choice Set A:

1.) Scale back and keep a few production lines open. Exactly 400 jobs will be lost out of 600.

2.) Invest in new equipment that may or may not improve your competitive position. There is a 1/3 chance that no jobs will be lost but a 2/3 chance that all 600 jobs will be lost.

Half of you were given Choice Set B:

1.) Scale back and keep a few production lines open. Exactly 200 jobs will be saved (out of 600 threatened with layoff).

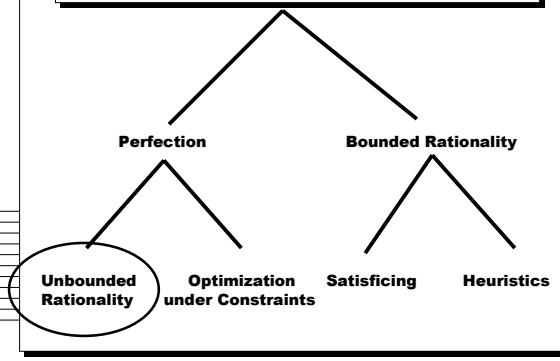
2.) Invest in new equipment that may or may not improve your competitive position. There is a 1/3 chance that all jobs will be saved but a 2/3 chance that none of the 600 jobs will be saved.

Differences Violate Frame Invariance

The Rationality Spectrum

How rational are we?

The Rationality Spectrum



Unbounded Rationality

- **IF we use probability correctly and IF we observe all the axioms of expected utility correctly, then you could call us "unboundedly rational".**
- ***Seems pretty difficult for our human brains, n'est ce pas?***

Unbounded Rationality—1

- *Why do people (mostly economists) make the "unbounded" rationality assumption?*
- Market forces: competition will drive out "losers"
  - Evolutionary survival of the fittest . . .
- *But, do* markets eliminate irrationality?
  - Arrow (1982)
  - Russell and Thaler, Lee Shleifer & Thaler
    - » *Closed end funds*
  - De Long, Shleifer, Summers and Waldman (1990)
    - » *"noise traders" do not necessarily lose money*

Unbounded Rationality—2

- *Why is the unbounded rationality assumption made? (take two)*
- The "as if" defense: we clearly don't understand the physics of catching a ball but our mind rationally acts *as if* it does
  - **i.e. we don't have to *understand* that we're being rational to be rational**
- **Bottom line:** Rationality assumes the decision maker has essentially unlimited or supernatural reasoning power
  - Example: fault tree . . .

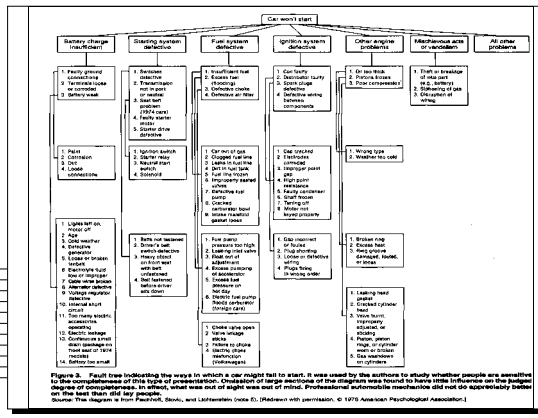


Figure 3. Fault tree indicating the ways in which a car might fail to start. It was used by the authors to study whether people are sensitive to the completeness of this type of presentation. Omission of large sections of the diagram was found to have little influence on the judged degree of completeness. In effect, what was out of sight was out of mind. Professional automobile mechanics did not do appreciably better on the test than did lay people.
Source: The diagram is from Fischhoff, Slovic, and Lichtenstein (note 6). [Reprinted with permission. © 1978 American Psychological Association.]

Darwin: "This is the Question"

- **To MARRY**
  - **Children—(if it please God)—constant companion, (friend in old age) who will feel interested in one, object to be beloved and played with-better than a dog anyhow.**
  - **Home and someone to take care of house--Charms of music and female chit chat. These things good for one's health.**
  - **Forced to visit and receive relations *with terrible loss of time.***
  - **My God, it is intolerable to think of spending one's whole life, like a neuter bee, working, working and nothing after all. No won't do. Imagine living all one's day solitarily in smokey dirty London House. --Only picture yourself a nice soft wife on a sofa with a good fire, and books and music perhaps--compare this vision with the dingy reality of Grt. Marlboro St.**
- ***or* Not To MARRY**
  - **No Children, (no second life) no one to care for one in old age….**
  - **Freedom to go where one liked-Choice of society and *little of it.***
  - **Conversation of clever men at clubs.**
  - **Not forced to visit relatives, and to bend in every little trifle.**
  - **To have the expense and anxiety of children--perhaps quarrelling.**
  - ***Loss of time*--cannot read in the evenings--fatness and idleness--anxiety and responsibility.**
  - **Less Money for books etc- if many children forced to gain one's bread. (But then it is very bad for one's health to work too much.)**
  - **Perhaps my wife won't like London, then the sentence is banishment and degradation with indolent fool--**

The Problem with Unbounded Rationality

- **"The greatest weakness of unbounded rationality is that it does not describe the way real people think."**

The 2/3 M Contest

- All contestants submitted a number below between 0 and 100. The <u>average</u> (mean) of all the submissions by all students will be a number, let's call it M. The winner of the contest is the person who submits the number closest to 2/3 M.
- How should one answer this question?
  - What is the "correct" answer?

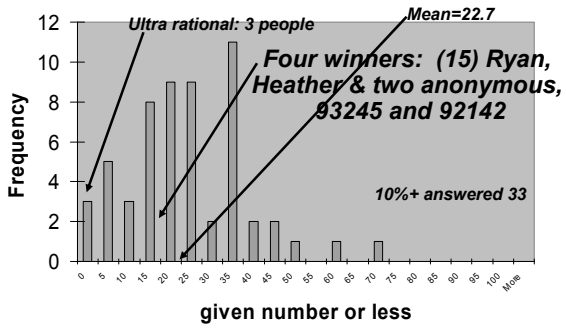
2/3 M Quotes

- 0
  - "This is the only number that is 2/3 of itself"
    - » (from ultrarationalist Adam)
- 1
  - "This is the loneliest number that you've ever seen"
- "I am sure, nobody will submit number over 66, because that is 2/3 of average if everybody entered the maximum of 100."
  - Oh yeah????

2/3 M Explanations

- "I assume most people will assume that the numbes are randomly distributed between 0-100 and therefore 2/3M will be ~67. Therefore, 67 will wind up being the mean and my choice is approx 2/3 of 67.
- "Average depends on what you think other students will input. The more they "get it" the lower the number will be driven.
- "The rational number is something like 0. However, I'll assume people will only use, on average, 3rd or 4th order thinking, that gets me around 25.
- "First assume avg=50. Therefore 2/3M would be 33.33 If most people calculate that, then may enter 33.33. Therefore, assume the new avg=33.33. So, 2/3M would be 22.2. If most of the people now pick 22, the going one step further, for 2/3 (22), I entered 15.
  - But, why stop there? Apparently, most people did. . . (from winner, 93245)
- "Lucky number"
  - Winner: 92142

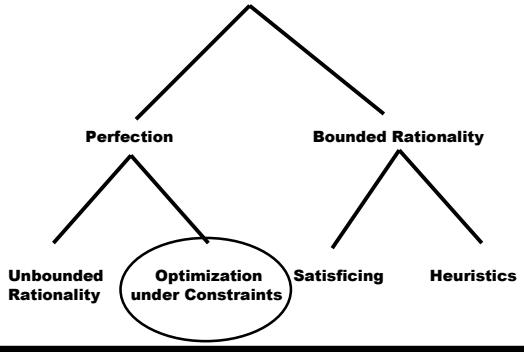
2/3s M Contest



The Problem with Unbounded Rationality

- *". . . . it does not describe the way real people think."*
- So, if we abandon the "logic of rational choice", where do we find ourselves?
- *What alternatives <u>better</u> describe real peoples' choices?*

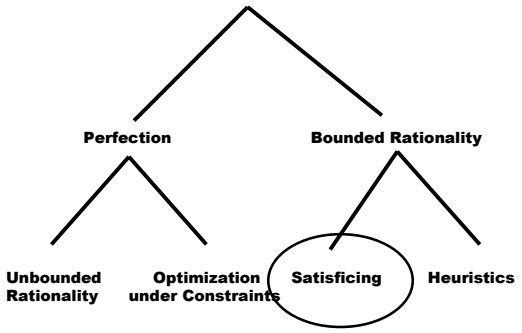
The Rationality Spectrum



Optimization under Constraints

- **Key difference between Unbounded Rationality and Optimization?**
- **Limited information search . . . Focus on maximizing key variables subject to a limited number of constraints**
  - **Compare all consequences (in unbounded) vs. searching for the most important issues, then deciding when to stop searching**
  - **Must determine the costs of continuing to search**
  - **Still, assumption that the mind has essentially unlimited time and knowledge to evaluate the costs and benefits of further search**
- **Examples: ??????**

The Rationality Spectrum



Bounded Rationality: Satisficing

- **Herbert Simon, Nobel laureate, observed:**
  - **that the human mind has limitations, the unboundedly rational view is unrealistic**
  - **that real decisions usually are not made by exhausting all possible alternatives**
  - **that what we actually observe humans doing is, rather than continue to search for the *optimal* decision, to stop and choose when an *acceptable* alternative is found**
- *We Satisfice . . .*

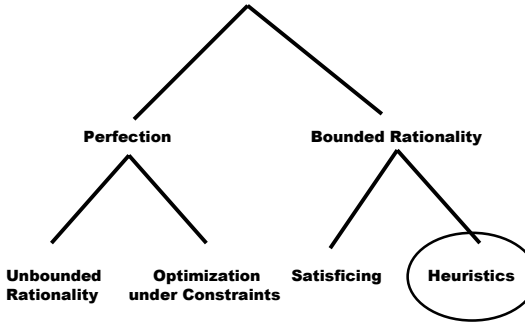
Satisficing

- When we encounter decision choices sequentially, **satisficing** is our method for making a choice.
- **Big Issue**: when to stop searching ?
- Satisficing is taking the shortcut of setting an acceptable level, and stopping search once that level is reached.
  - Acknowledges uncertainty and limited time to decide
- **Example**: Job Searching . . .or Darwin's question again*!!!* . . .

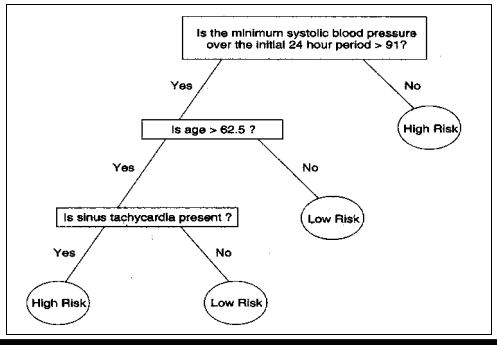
Optimal Satisficing: Heuristics

- **What is an optimal "model" of *satisficing*?**
- **We need three principles:**
  - **Principles for guiding search . . .**
    - » **Where, how do I search for an answer?**
  - **Principles for stopping search . . .**
    - » **How to know when I have enough alternatives to choose among?**
  - **Principles for decision making . . .**
    - » **What "rule" do I use to choose among my alternatives?**

The Rationality Spectrum



Decision Tree: Heart attack triage



Bounded Rationality: Heuristics

- What makes a good heuristic?
  - **Remember, heuristics trade off "speed" vs. "accuracy"**
- ***Informationally frugal***
- ***Robustness***
  - **Not Overfitting . . . .**
    - » **Question: is it possible that more information is actually *worse* for our decision process?**
- ***What else?***