Spring 2021

Section 1 (DSSA)

Decision Tables

- The aim of decision analysis is to select the best decision, among a number of decision alternatives, when the future is uncertain.
- The main objective is to optimize the resulting payoff in terms of a decision criterion.
- Maximizing expected profit is a common criterion when probabilities can be assessed.
- Maximizing the decision maker's utility function is the mechanism used when risk is factored into the decision-making process.

Payoff Table:

- A useful way to represent and analyze a scenario where there is a range of possible outcomes and a variety of possible responses. A payoff table simply illustrates all possible profits/losses.
- The rows correspond to the possible decision alternatives
- The columns correspond to the possible future events.
- Future events (states of nature) are mutually exclusive and collectively exhaustive.
- The table entries are the payoffs.

Example:

- Tom Brown has inherited $1000.
- He has to decide how to invest the money for one year.
- A broker has suggested five potential investments.
  - Gold
  - Junk Bond
  - Growth Stock
  - Certificate of Deposit
  - Stock Option Hedge
- The return on each investment depends on the (uncertain) market behavior during the year.
- Tom would build a payoff table to help make the investment decision

Decision Alternatives	States of Nature				
	Large Rise	Small Rise	No Change	Small Fall	Large Fall
Gold	-100	100	200	300	0
Bond	250	200	150	-100	-150
Stock	500	250	100	-200	-600
C/D account	60	60	60	60	60
Stock option	200	150	150	-200	-150

The stock option alternative is dominated by the bond alternative

Decision Making Criteria:

1. **Decision making under certainty.**
   - The future state-of-nature is assumed known.
2. **Decision making under uncertainty.**
   - There is no knowledge about the probability of the states of nature occurring.
3. **Decision making under risk.**
   - There is some knowledge of the probability of the states of nature occurring.

Decision Making under uncertainty:

- The decision criteria are based on the decision maker's attitude toward life.
- The criteria include:
  1. Maximax Criterion - optimistic or aggressive approach.
  2. Maximin Criterion - pessimistic or conservative approach.
  3. Criterion of Realism (Hurwicz)
  4. Equally Likely (La Place)
  5. Minimax Regret Criterion - pessimistic or conservative approach.

Maximax Criterion:

- This criterion is based on the best possible scenario. It fits both an optimistic and an aggressive decision maker.
- An optimistic decision maker believes that the best possible outcome will always take place regardless of the decision made.
- An aggressive decision maker looks for the decision with the highest payoff (when payoff is profit).
- To find an optimal decision.
  - Find the maximum payoff for each decision alternative.
  - Select the decision alternative that has the maximum of the "maximum" payoff.

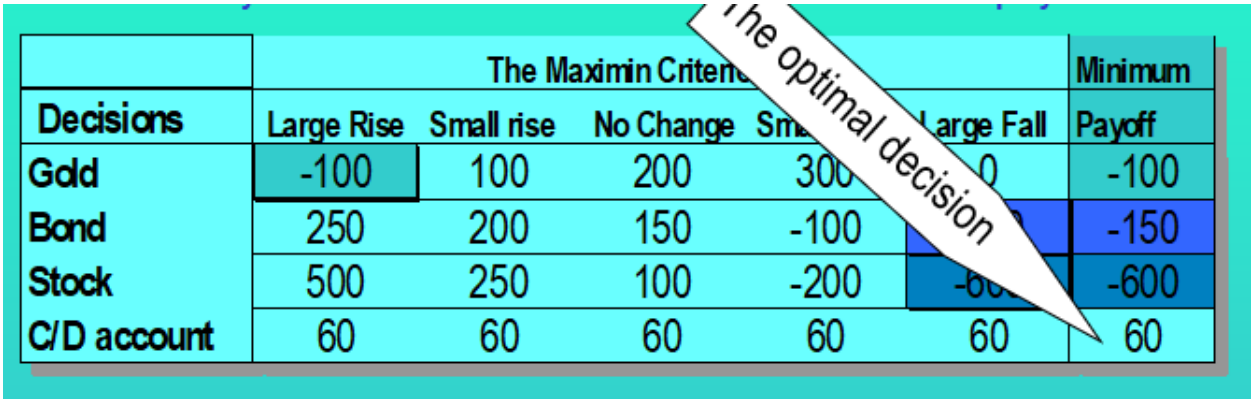
The optimal decision

Decision	The Maximax Criterion					Maximum Payoff
	Large rise	Small rise	No change	Small fall	L… …ll	
Gold	-100	100	200	300	…	300
Bond	250	200	150	-100	-150	200
Stock	500	250	100	-200	-600	500
C/D	60	60	60	60	60	60

Therefore, the optimal decision is (Stock)

Maximin Criterion:

- This criterion is based on the worst-case scenario.
  - It fits both a pessimistic and a conservative decision maker's styles.
  - A pessimistic decision maker believes that the worst possible result will always occur.
  - A conservative decision maker wishes to ensure a guaranteed minimum possible payoff.
- To find an optimal decision
  - Record the minimum payoff across all states of nature for each decision.
  - Identify the decision with the maximum "minimum payoff."



Decisions	The Maximin Criterion					Minimum
	Large Rise	Small rise	No Change	Sm…	…Large Fall	Payoff
Gold	-100	100	200	300	0	-100
Bond	250	200	150	-100	…	-150
Stock	500	250	100	-200	-60…	-600
C/D account	60	60	60	60	60	60

Therefore, the optimal decision is (C/D account)

Criterion of Realism (Hurwicz):

- A weighted average compromises between optimistic & pessimistic.
- To find an optimal decision, for **each state of nature:**
  - Select a coefficient of realism α, between 0 and 1.
  - A value of 1 is 100% optimistic
  - Compute the weighted average for each alternative.
  - Select the decision alternative with the highest average.
  - $\alpha(maximum\ in\ row) + (1 - \alpha)(minimum\ in\ row)$

$\boldsymbol{Let\ \alpha = 0.7}$	
Decisions	**Criterion of Realism**
Gold	= (0.7) (300) + (0.3) (-100) = 180
Bond	= (0.7) (250) + (0.3) (-150) = 130
Stock	= (0.7) (500) + (0.3) (-600) = 170
C/D account	= (0.7) (60) + (0.3) (60) = 60

Therefore, the optimal decision is (Gold)

Equally Likely (La Place):

- Consider all the payoffs for each decision alternative.
- Find the average payoff, for **each decision alternative.**
- Select the decision alternative with the highest average.

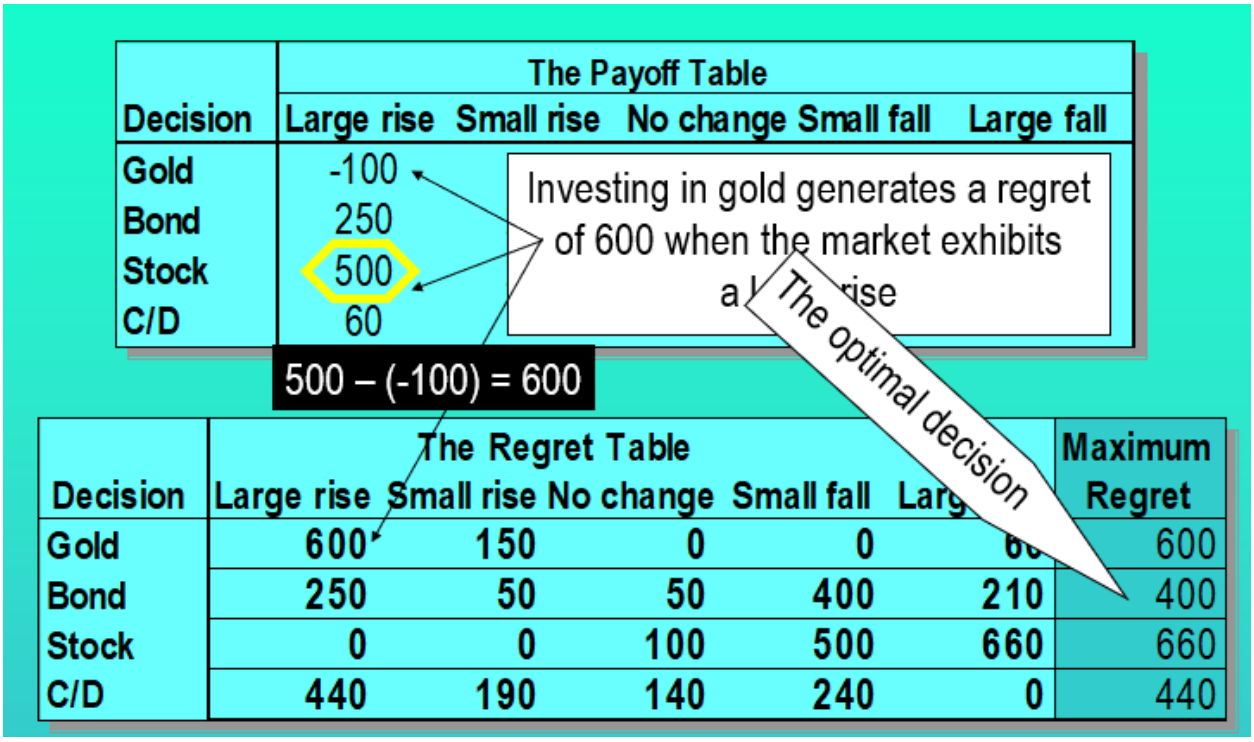
Equally Likely	
Decisions	**Average Payoff**
Gold	= Average (-100, 100, 200, 300, 0) = 100
Bond	= Average (250, 200, 150, -100, -150) = 70
Stock	= Average (500, 250, 100, -200, 600) = 250
C/D account	= Average (60, 60, 60, 60, 60) = 60

Therefore, the optimal decision is (Stock)

Minmax Regret(opportunity loss) Criterion:

- This criterion fits both a pessimistic and a conservative decision maker approach.
- The payoff table is based on "opportunity loss," or "regret."
- The decision maker incurs regret by failing to choose the "best" decision.

- To create an opportunity loss (regret) table:
  - Determine the best payoff over all decisions.
  - Calculate the regret for each decision alternative as the difference between its payoff value and this best payoff value.
- To find an optimal decision:
  - For each decision find the maximum regret over all states of nature.
  - Select the decision alternative that has the minimum of these "maximum regrets."



Therefore, the optimal decision is (Bond)

Decision Making under risk:

- The probability estimates for the occurrence of each state of nature (if available) can be incorporated in the search for the optimal decision.
- For each decision calculate its EMV (expected monetary value) or Expected value.

The EMV criterion:

$$\text{Expected Payoff} = \Sigma(\text{Probability})(\text{Payoff})$$

- The summation is calculated across all the states of nature
- Select the decision with the best expected payoff

Let's assume that the future events (states of nature) have probabilities of occurrences; 20%, 30%, 30%, 10%, 10%; respectively.

NOTE: Sum of probabilities must be equal 100%

The optimal decision

Decision	The Expected Value Criteri… Large rise	Small rise	No change	Small fall	…	Expected Value
Gold	-100	100	200	300	0	100
Bond	250	200	150	-100	-150	130
Stock	500	250	100	-200	-600	125
C/D	60	60	60	60	60	60
Prior Prob.	0.2	0.3	0.3	0.1	0.1	

EV = (0.2)(250) + (0.3)(200) + (0.3)(150) + (0.1)(-100) + (0.1)(-150) = 130

Therefore, the optimal decision is (Bond)

Expected value of perfect information (EVPI):

- The gain in expected return obtained from knowing with certainty the future state of nature.
- It places an upper bound on what you should pay for additional information.
- EVPI = EVWP – Maximum EMV
- EVWP is expected value with perfect information, which states the long run average return if we have perfect information before a decision is made.

If it were known with certainty that there will be a "Large Rise" in the market

Decisior	-100	cted Value of Perfect Information Small rise	No change	Small fall	Large fall
Gold	250	100	200	300	0
Stock	500	200	150	-100	-150
		250	100	-200	-600
C/D	60	60	60	60	60
Probab.		0.3	0.3	0.1	0.1

Decision	-100	cted Value of Perfect Information Small rise	No change	Small fall	Large fall
Gold	250	100	200	300	0
Bond	500	200	150	-100	-150
Stock		250	100	-200	-600
C/D	60	60	60	60	60
Probab.		0.3	0.3	0.1	0.1

EVWP = (0.2) (500) + (0.3) (250) + (0.3) (200) + (0.1) (300) + (0.1) (60) = $271

DSS App (Section #2 continued).mp4

EVPI = $271 - $130 = $141

This means, that the max which the decision maker can pay for additional information is $141

Expected opportunity loss (EOL):

- The cost of not picking the best solution.
  - First, construct an opportunity loss (regret) table.
  - For each decision alternative, multiply the opportunity loss by the probability of that loss for each possible outcome and add these together
- Minimum EOL will always result in the same decision as maximum EMV.
- Minimum EOL will always equal EVPI

The Opportunity loss (Regret) table					
Decisions	**Large rise (0.2)**	**Small rise (0.3)**	**No change (0.3)**	**Small fall (0.1)**	**Large fall (0.1)**
Gold	600	150	0	0	60
Bond	250	50	50	400	210
Stock	0	0	100	500	660
C/D account	440	190	140	240	0

- EOL of Gold = (0.2) (600) + (0.3) (150) + (0.3) (0) + (0.1) (0) + (0.1) (60) = 171
- EOL of Bond = (0.2) (250) + (0.3) (50) + (0.3) (50) + (0.1) (400) + (0.1) (210) = 141
- EOL of Stock = (0.2) (0) + (0.3) (0) + (0.3) (100) + (0.1) (500) + (0.1) (660) = 146
- EOL of C/D account= (0.2) (440) + (0.3) (190) + (0.3) (140) + (0.1) (240) + (0.1) (0) = 211

Sensitivity Analysis:

- Sensitivity analysis examines how our decision might change with different input data
- Will be explained on the example in Lecture 3 (Slide 4).

If you have any questions, email me at r.bidweihy@fci-cu.edu.eg

Best of Luck!

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