Aston Business School

Week 4
Decision-making under risk

BN2255 – Business Analytics in Practice

PizzaNova Problem

- PizzaNova is contemplating opening a new pizza place on Queen Street. It has three different models, each with a different seating capacity. PizzaNova estimates that the average number of customers per hour will be 80, 100, or 120 and based on these figures has estimate the profit likely to be achieved under the different models.

Models	Average Number of Customers Per Hour		
	$s_1 = 80$	$s_2 = 100$	$s_3 = 120$
Model A	£10,000	£15,000	£14,000
Model B	£ 8,000	£18,000	£12,000
Model C	£ 6,000	£16,000	£21,000

Decision Making Procedure

1. Identify and formulate the main decision question
2. List all the plausible decision alternatives
3. Decide what to measure when evaluating outcomes
4. Identify all the uncontrollable factors that may influence the outcome and if possible the likelihoods of their occurrence – states of natures with or without probabilities
5. Determine the consequence for each possible scenario
6. Select and apply the method to make a decision

PizzaNova Decision Problem

1. Identify and formulate the main decision question
   - Which model should the new pizza place use?
2. List all the plausible decision alternatives
   - Models A, B or C
3. Decide what to measure when evaluating outcomes
   - Each model has a different seating capacity and will result in different profit levels based on actual demand
4. Identify the different states of nature (with or without probabilities)
   - Low, Medium or High demand
5. Determine the consequence for each possible scenario
   - Different profit levels per model and actual demand, as per the payoff table
6. Select and apply the method to make a decision

Making Decisions Without Probabilities

- Some commonly used criteria for decision making under uncertainty when probability information regarding the likelihood of the states of nature is unavailable are:
  - Maximax criterion (optimistic)
  - Maximin criterion (conservative / pessimistic)
  - Minimax regret criterion (opportunity loss)
  - Hurwicz criterion (balanced)
  - LaPlace criterion (equal likelihood)

- Not the focus for this module but for more information, see:
  - Wisniewski – Chapters 5 & 6
  - Curwin & Slater – Chapter 8

Making Decisions With Probabilities

Expected Value Criterion:

Select i (d_i) for which **EV = max EV$_i$ = max** $\sum_j p_j C_{ij}$

Expected Regret Criterion:

Select i (d_i) for which **ER = min ER$_i$ = min** $\sum_j p_j R_{ij}$

Expected Value of Perfect Information (EVPI):

EVPI = EVwPI – max EV$_i$ = min ER$_i$

PizzaNova Problem – Expected Values

Models	Average Number of Customers Per Hour			
	low (s_1) $p_1 = 0.4$	*medium* (s_2) $p_2 = 0.2$	*high* (s_3) $p_3 = 0.4$	***EV***
A (d_1)	£10,000	£15,000	£14,000	£12,600
B (d_2)	£ 8,000	£18,000	£12,000	£11,600
C (d_3)	£ 6,000	£16,000	£21,000	**£14,000**

Select i (d_i) for which $\mathbf{EV = max\ EV_i = max} \sum_j p_j C_{ij}$

PizzaNova Problem – Expected Regret

	Average Number of Customers Per Hour			
Models	*low* (s_1) $p_1 = 0.4$	*medium* (s_2) $p_2 = 0.2$	*high* (s_3) $p_3 = 0.4$	***ER***
A (d_1)	£0	£3,000	£7,000	£3,400
B (d_2)	£ 2,000	£0	£9,000	£4,400
C (d_3)	£ 4,000	£2,000	£0	**£2,000**

Select i (d_i) for which $\mathbf{ER = \min ER_i = \min} \sum_j p_j R_{ij}$

PizzaNova Problem – Expected Value of Perfect Information

	Average Number of Customers Per Hour			
Models	*low* (s_1) $p_1 = 0.4$	*medium* (s_2) $p_2 = 0.2$	*high* (s_3) $p_3 = 0.4$	***EV***
A (d_1)	**£10,000**	£15,000	£14,000	£12,600
B (d_2)	£ 8,000	**£18,000**	£12,000	£11,600
C (d_3)	£ 6,000	£16,000	**£21,000**	**£14,000**

EVwPI = 0.4(£10,000) + 0.2(£18,000) + 0.4(£21,000) = £16,000

EVPI = EVwPI – max EV_i = £16,000 = £14,000 = £2,000

Expected Value and Expected Utility

- In some cases, the notion of expected value is flawed
  - 10% of winning £10 million pounds (EV= £1 million)
  - 99% of winning £1 million pounds (EV= £0.99 million)
  - Which one would you choose?
- Certainty has **utility** and the value of money is subjective (what would Bill Gates decide?)
- Behavioural economics links
  - http://economicspsychologypolicy.blogspot.co.uk/2013/09/lecture-on-rationality-utility-value.html
  - ftp://grey.colorado.edu/pub/oreilly/teach/introcog/icog_decision.pdf
- That does not mean that the notion of expected value is not useful!
  - if utility and value are likely to be very different, we can adjust values (pay-offs) to better reflect utility
  - The main goal is to create a framework that allows for rational decision-making!

Sequential Decisions

PizzaNova has an option to purchase a marketing survey from MM Marketing for £1,000. The results of the survey are "favorable" or "unfavorable". The following probabilities were obtained from the historical records of MM Marketing:

$p(\text{favorable}) = 55\%$
$p(s_1 \mid \text{favorable}) = 15\%$
$p(s_2 \mid \text{favorable}) = 20\%$
$p(s_3 \mid \text{favorable}) = 65\%$

$p(\text{unfavorable}) = ??$
$p(s_1 \mid \text{unfavorable}) = 70\%$
$p(s_2 \mid \text{unfavorable}) = 20\%$
$p(s_3 \mid \text{unfavorable}) = 10\%$

Should PizzaNova order a survey from MM Marketing?

[see Model answers spreadsheet for a model solution]