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Information

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Problem 1

You are thinking of applying to an international analytics trainee programme and you have come up with three attributes to evaluate the alternatives. The evaluation is based on the additive model $u(x_1, x_2, x_3) = \sum_{i=1}^{3} w_i\, u_i(x_i)$.

The attributes are the *length of employment* (i=1), *rating* of the programme given by previous candidates (i=2), and *distance* from your home country (i=3). The measurement scales of these attributes are [9,24] months, {1,2,3,4,5} stars, and [0 km, 3000 km], respectively.

The attribute specific utilities are:

- Attribute 1 has a linear utility (the longer employment the better)
- Attribute 2 has utilities: $u_2(1star) = 0$, $u_2(2stars) = 0.5$, $u_2(3stars) = 0.7$, $u_2(4stars) = 0.85$, $u_2(5stars) = 1$
- Attribute 3 has utilities that are consistent with the following internal dialogue:
  - *I want the location of the company be far from home rather than near*
  - *Then if I have locations A and B that are equally preferred on attributes 1 and 2, and distance for A is uncertain with 50-50 chance of being either 0 or 3000 km, then what would be a certain distance for B so that A and B are equally preferred? That would be around 1000 km*
  - *For simplicity I will use a piecewise linear utility function that is consistent with* $x_3^0 = 1000$

Question 1

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a) Implement the utility functions u_1, u_2, u_3 on the answer template file. Scale the utilities so that most preferred performance level gets attribute-specific utility of one and the least preferred performance level the utility of zero. Check that your model is correct up to this step by inputting an alternative $x^{check} = (12, 3, 2100)$ that should give attribute-specific utilities of 0.2, 0.7, and 0.775, respectively.

Then you start thinking about the relative importance of each attribute, i.e. the attribute weights. You make internally the following two observations about your preferences:

- If there are two destinations C and D that have outcomes $x^C = (24, 1star, 3000)$ and $x^D = (x_1^D, 5stars, 3000)$, you would think that a level of $x_1^D = 15$ would make C and D equally preferred
- If there are two destinations E and F with outcomes $x^E = (7.5, 1star, 3000)$ and $x^F = (7.5, 5stars, 0)$, then E and F would be equally desirable for you.

b) Estimate attribute weights w_1, w_2, w_3 so that they sum to one and implement the overall utility function on the answer template. The alternative x^{check} should give an overall utility of about 0.49.

c) Compute the expected utilities for the following three alternatives using your model (note that the alternative Barcelona has not had its rating information published yet, therefore it has uncertainty in the Rating attribute):

Alternative	Length of employment (months)	Rating of the programme	Distance (km)
Dublin	18	5 stars	2000
Wien	9	4 stars	1500
Barcelona	24	(3 stars,0.4; 4 stars,0.6)	2600

Excel template for Problem 1

problem1_Nguyen Xuan Binh_887799.xlsx

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Problem 2

Grocery retailers are selling fresh foods and constantly face uncertainty regarding the freshness of their supply. In developed countries more than 2/3 of food waste is generated at the retail and consumption stages of the supply chain. Recently, there have been technological solutions based on Blockchain to reduce food waste, such as the Food Trust by IBM. In essence, blockchain offers more precise information sharing regarding freshness of supply across the whole supply chain and allows the retailers to optimise their inventories better.

For this problem you can submit either an Excel or a Jupyter Notebook file, no template is given. Formulate your model so that it is easy to check. If you use Excel, include all answers on the same worksheet.

Question 2

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a) Consider first a retailer that is not using blockchain. Their consumer demand is stochastic and freshness-dependent: $D = \lambda + \beta X + \epsilon$, where λ is a baseline level of demand, β is sensitivity of demand to freshness, and X and ϵ are independent normally distributed random variables, such that $X \sim N(0, \sigma_X^2)$ and $\epsilon \sim N(0, \sigma^2)$. The variable ϵ describes an idiosyncratic demand shock and the variable X describes uncertain freshness of supply. For simplicity the variable X is mean-centred at zero.

Model this problem using Excel, Python or R. Assume that the baseline level of demand is $\lambda = 357.46$ kg, sensitivity is $\beta = 82.38$ kg/day, and $\sigma = 44.72$ and $\sigma_X = 0.6509$. Assume also that the retailer buys its stock with wholesale price 1 eur/kg and sells it with retail price 3 eur/kg. There is no salvage value with the stock that is unsold. The retailer is risk-neutral and maximises profit. Use the model to answer the following questions: what is the optimal level of fresh food to stock, and what is the associated expected profit with that level?

b) Now consider a Blockchain retailer who receives freshness information, i.e. knows the realisation $X = x$ before ordering. Note that even in this case the supply order may not match demand because of the component ϵ whose realisation is not observed before decision making. Use the model to answer the following questions: What is the improvement in expected profit with a retailer that is using Blockchain? How much less food waste is produced?

Hint: simulate values of X and ϵ to calculate demand. The retailer can only profit from the stock that is sold, i.e. overage stock is costly but does not contribute to profit. The problem is similar to the hotel room optimisation problem from Assignment 1.

problem2_Nguyen Xuan Binh_887799.ipynb

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Problem 3

Franco Motors is introducing a new electric car model and is looking for input from test drivers. The marketing team has decided to send rounds of invitations to test drive the new model to two target groups: (1) current owners of an earlier model of Franco Motors, and (2) owners of electric cars manufactured by one of Franco Motors' competitors. They can use three different marketing channels: direct mail, text messages, and social media. The channels and their reach as well as cost and maximum capacities are shown in the table below.

Channel	Current owners reached	Competitor model owners reached	Cost per round of invitations (€)	Max number of messages
Text messages	900	1200	750	2500
Direct mail	1400	300	900	9000
Social media	300	3000	500	11000

Franco Motors uses an additive value model with concave attribute-specific value functions of the form $v_i(x_i) = \sqrt{x_i}$ for i = 1,2, where x_1 is the number of current owners reached and x_2 is the number of competitor model owners reached.

It is known that the more rounds of invitations the company sends, the more likely it is that the target customers arrive for a test drive. The company would like to maximize the number of customers that come for a test drive from both groups, but they also think that the groups are not equally important. They think that it is more important to reach current owners than competitor model owners, therefore they have assessed that an outcome (0 competitor model owners, 100 current model owners) is equally preferred to an outcome (300 competitor model owners, 0 current model owners). They also have a budget constraint of 7,000€ for this campaign.

Question 3

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a) What are values of the attribute weights in the additive value function $v(x) = \sum_{i=1}^{2} w_i\, v_i(x_i)$? Explain how you derive the weights (i.e. use the tradeoff method and the indifference statement). You can assume that $v_i(0) = 0$ for i = 1,2.

1. Indifference statement:
Franco Motors is indifferent between reaching 0 competitor model owners and 100 current model owners (Outcome A) versus reaching 300 competitor model owners and 0 current model owners (Outcome B).

We now define the weights for the value functions of the current model owners and competitor model owners as w1 and w2

The total value function
v([x1, x2]) = w1 * v1(x1) + w2 * v2(x2)
=> v([x1, x2]) = w1 * sqrt(x1) + w2 * sqrt(x2)

From the indifference statement, we have the tradeoff method as follows

w1 * v1(100)+w2 * v2(0) = w1 * v1(0)+w2 * v2(300)
=> w1 * sqrt(100)+w2 * sqrt(0) = w1 * sqrt(0)+w2 * sqrt(300)
=> w1 *10 = w2 * 10 * sqrt (3) => w1 = sqrt(3) * w2

We need to normalize the weight such that sum of weight: w1 + w2 = 1
=> w1 = sqrt(3)/(1+ sqrt(3)) = 0.633974596 (answer)
w2 = 1/(1 + sqrt(3)) = 0.366025404 (answer)

Question 4

Flag question Marked out of 4.00 Complete

b) Use the Excel template and use Solver to find the number of invitation rounds to send through each of the channels that maximize v(x) while satisfying all the constraints. An invitation round means that one message (text, direct mail letter, or social media post) is sent to each person from each group. One person can therefore be reached multiple times. **Include the Solver Answer Report** in another sheet at your submission file.

Excel template for Problem 3

problem3_Nguyen Xuan Binh_887799.xlsx

Question 5

Flag question Marked out of 2.00 Complete

c) The Head of Analytics at Franco Motors gives a visiting lecture for local business school students and claims that this is a non-linear convex problem with continuous decision variables. Is he correct in this statement? Justify your answer briefly.

His statement is partially wrong. We need to analyze each component of his statement

This is a nonlinear, convex problem with continuous decision variables

1) First, he is correct that this is a nonlinear problem, since the value function is a weighted sum of square roots of number of customers
2) Second, he is wrong regarding convex problem. This should be a concave problem since the square root function has a second derivative that is negative for its entire domain
3) Third, he is wrong regarding continuous decision variables. The company must send out the media to the customers in a full rounds, not a partial round. Therefore, the decision variables should be integer instead

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Problem 4

This problem consists of completing the Key Terms test and Course Feedback, from which you will receive real points towards the assignment:

- 3 points: complete the **Key Terms test** that will be available on 12 February; this will help you to assess your knowledge and understanding of the whole course content before the exam (you will get the points whether or not your answers are correct)
- 3 points: fill in the **Course Feedback** survey (anonymous) that will open on 12 February; this is very helpful for us in developing the course for next year

Finish review

Previous activity

Assignment 2