GRA 4138 Business Simulation Analysis – Spring semester 2023

Your team of consultants (groups of 2-3 students) are up for promotion in your firm, and you must provide evidence to demonstrate your teams:

1) Ability to use simulation approaches to solve real world problems, document the models in a non-technical manner and, make clear recommendation to clients
    a. **Part A (10%) Monte Carlo simulation:** Supermarket chocolate case, pg.2-3.
    b. **Part B (80%) Simulation:** The Queen Vic pub case, pg.4-8.

2) Theoretical understanding of key simulation paradigms and concepts
    a. **Part C (10%) Critical essay:** Review two simulation papers from 2022, pg.9-10.

Important rules

- The models and reports must be developed and prepared by each group individually. Collaboration with other groups is not permitted and considered cheating.

Notes

- **Submission**:
    - A single report with parts A, B and C clearly labelled.
    - A single ZIP file containing the Monte Carlo simulation Excel file, AnyLogic model(s), and Supporting material/appendices.
- The Monte Carlo simulation model must be built in Excel
- The AnyLogic model must be executable in the AnyLogic Personal Learning Edition

If you experience technical problems during the exam:

- Check portal.bi.no to see if you find a solution.
- In case of problems with your digital exam, contact InfoHub: info@bi.no.

Part A: Monte Carlo Simulation (10%)

1. A BRIEF report (3 pages maximum, including appendices) for the supermarket manager.
2. The Excel file containing your model. The first worksheet in this Excel file should contain your model. You can add additional worksheets if needed, clearly named, showing any results and analyses. You can also add comments for me, e.g., describing functionality, purpose of experiment etc: the client will not see the Excel file, so you can be technical.

Report (Non-technical report/executive summary)

Your report to the manager should be written in plain, non-technical language and presented in a professional manner appropriate for a business consultancy. It should start with a brief Executive Summary stating your recommendation(s)/finding(s). **Do not repeat any of the term paper text**: a) it wastes words and b) the manager already knows. They will want to understand the reasons behind your conclusion(s), and you will need to convince them that your results are reliable. You will need to describe **IN SIMPLE TERMS** what the model does. You can use graphs and tables where you think it would help. This is not an academic essay, it is a client report, so do not include any academic references.

Grading criteria

Description	**Marks**
Excel model logic correct	25
Excel sheet(s) clearly laid out	5
Experimentation performed correctly	10
Shows understanding of MCS	30
Report – layout and presentation	5
Report – clarity of explanation, no jargon	25
	100

Of course, developing a suitable model is important, but showing that you understand the underlying principles of Monte Carlo simulation and can explain them to a non-technical client is equally important. As you can see from the grading criteria, you can still get a good mark for this assignment even if your model contains minor errors.

Supermarket Chocolate

Your local supermarket has 200 bags of Smash and 100 bars of Kvik lunsj chocolate in stock. The expected demand for Kvik lunsj on any day is Poisson Distributed with a mean of 85, for Smash the expected demand is uniformly distributed between 190 and 250. For those who were unable to buy Smash 50% will buy a Kvik lunsj instead if any are in stock. Using Monte Carlo simulation in Excel, after running at least 2000 replications, what is the probability that all 300 items will be sold?

Your short report could contain:

- Summary statistics (mean, confidence intervals)
- Probability distribution of total sales (histogram, use sensible bin sizes)
- Recommendations for alternative policy or further analysis
- Appendix how demand was generated

Part B: Simulation – (80%)

1. A report containing the following:
    a. A non-technical section (3 pages maximum) for the owners of the Queen Vic pub
    b. A table of context
    c. A technical section (12 pages maximum, excluding appendices).
    d. You may add as many appendices as necessary. (e.g., Data tables, maps, results, etc), but they must serve a purpose and be cited in the technical report.
2. The AnyLogic model, with:
    a. a simulation related to the base case,
    b. one or more simulation(s) relating to "what-if" scenario(s) you have tested
    c. one or more optimisation experiment(s)
3. Possibly supporting material. The reports are graded not the supporting material/appendices.

Report

For the non-technical section see **Part A** advice. The technical section could cover: Model conceptualisation, Data; Assumptions and their validity; Model Validation; Key logic of your model(s), e.g., functions, routing etc; Model outputs (KPIs); Scenarios and experimentation; Results and analysis; Conclusion and future work; References. Each group can use their discretion in terms of what is included/excluded from the report.

Grading criteria

Description	**Marks**
AnyLogic model logic correct	25
Model layout easy to understand	5
Experimentation performed correctly	10
Shows understanding of DES/ABM	30
Report – layout and presentation	5
Report – clarity of explanation, no jargon (1a), jargon permitted (1c)	25
	100

Obviously, getting the model right is important, but showing that you understand the underlying principles of DES/ABM and can explain them to a non-technical client is equally important. As for **Part A**, you can still get a good mark for this assignment even if your model contains minor errors.

Other relevant advice from previous term papers

- Structure and quality of the report as an academic text
- Making bug-free model(s) with sound logic
- Making a user friendly and intuitive interface for the model(s) (e.g., by using menus and controls)
- Defining and measuring relevant and creative performance indicators (KPIs) to analyse the performance under different scenarios and parameter values.
- Considering different scenarios and investigating their impact on the results
- Visualisation and animation of the project
- Use of relevant charts, diagrams and statistics in your analysis and simulation model(s)
- Validity, justification and relevance of assumptions and data (the model must be "good enough")
    - Referencing relevant papers, reports, case studies, websites and other documents and studies, is always advantageous.
- Performing at least one creative and relevant optimisation experiment
- Additional experiments such as parameter variation, calibration, or Monte-Carlo
- Identifying/suggesting changes/recommendations for the pub which can improve customer satisfaction and/or pub operations.

The Queen Vic

The owners of your favourite local pub "The Queen Vic" are considering converting some of the bar into a small restaurant. The owners have preliminary market research into the expected demand, but they are uncertain how many staff should be employed, and the capacity of the restaurant.

As a frequent customer the owners know that you and your team are experts in Business analytics and can build a simulation model to help them solve their problem. You ask the owners to summarise the key tasks, including customer arrival rates, group sizes, service times at the bar etc., and to collect relevant data for you. You visit a different pub with a restaurant to collect data on the time people spend ordering and eating food, and the numbers of guests in each group of diners. You observe that some of the diners have a drink in the bar before their meal, while others go straight to the restaurant.

There are two types of customers in your model; people who use the pub for drinking only (Drinkers), and people who use the restaurant (Diners). **Drinkers** arrive between 17.00 and 22.30, at random at a rate of one every 7 minutes. They join a queue for the bar, and then get served. You can assume this is a FIFO queue, although this is unlikely (certainly in the UK). The service time is uniformly distributed with min = 0.5 and max = 5 minutes. The time taken to drink is modelled by a triangular distribution with min = 10, mode = 20 and max = 30 minutes. After each drink there's an 85% chance that a customer will go back to the bar for another drink and a 15% that they will leave. Additionally, each drinker is assigned a maximum number of drinks (a limit) they can have from a discrete uniform distribution with min = 1 and max = 10, once they reach this limit, they will leave the bar irrespective of the outcome of the chance of having another drink.

Diners arrive between 17.00 and 21.00. The owners' market research indicates that diners will arrive in groups, at random, at a rate of one group every 12 minutes. The number of people in each group is described by the following PDF:

Number in group	Probability
1	0.10
2	0.40
3	0.20
4	0.30

Half the diners have a drink at the bar first, and half go straight to the restaurant. Diners who go straight to the restaurant join a queue to order food. Diners who have a drink at the bar first join the bar queue, have one drink, and then join the queue to order food.

Using data from the other pub, you fit a uniform distribution with min = 1 and max = 6 minutes to the Order activity. After people have ordered their food, they wait until a seat is free. The total time they spend at the table, which for simplicity you decide to model as one single activity (i.e., includes waiting to be served, eating, and the table being cleared afterwards), is described by a triangular distribution with min = 25, mode = 55 and max = 90 minutes. After this they leave.

You make four further simplifying assumptions, which make the model unrealistic but much easier to code:

1. Groups of diners do not stay together. Once a group has arrived, they get split up and are treated as separate individuals. So, for example, if a group of four diners arrive, two may decide to have a drink before the meal while the other two go straight to the restaurant.
2. All the tables in the restaurant are for one person. Therefore, the queue for the restaurant is just a normal FIFO queue, and groups do not have to sit together - or even leave together!
3. Food is brought to the table by the kitchen staff, who you do NOT have to model.

4. Ignore UK licensing laws, which require pubs to stop serving alcohol after 23:00, and ignore the small number of people who might still be eating or drinking after midnight.

Currently there are two people working behind the bar and one person taking food orders. The owners are planning to employ one extra person to take the food orders, and to have 12 seats in the restaurant. They tell you that acceptable waiting time criteria should be:

- At the bar, 95% of customers should be served in 5 minutes or less
- 95% of customers should have to wait 10 minutes or less to order food or get a seat.

Build an AnyLogic model for this system and use your model to advise the owners how many bar staff, food order staff, and restaurant seats there should be to satisfy the owners' criteria.

All the information you need to develop the model is provided in the case description above. Feel free to suggest alternative pub configurations, but clearly justify any assumptions and/or additional data required to test the proposed changes.

Part C: Critical essay of two simulation papers from 2022 (10%)

1. A critical essay of two simulation case study academic articles (1000-word limit, excluding reference section) based on the details below.

Details

Find two journal papers published in the year **2022** describing case studies in which one of the following techniques was applied 1) Discrete event simulation (DES); 2) Agent based modelling (ABM); 3) Monte Carlo simulation (MCS)

To avoid all possible confusion, you should end up with **TWO papers published in 2022**, do not choose two where the same technique has been applied, see table below.

Incorrect	Paper 1 = DES; Paper 2 = DES
	Paper 1 = ABM; Paper 2 = ABM
Correct	Paper 1 = DES; Paper 2 = ABM
	Paper 1 = MCS; Paper 2 = DES

You can select papers from any application area you like. Simulation is used across a vast range of disciplines, so select papers that interest you!

For each of your chosen papers:

a) BRIEFLY describe the features of the problem which in your view influenced the choice of technique.

b) Discuss whether it would have been possible to use a different approach for that problem. E.g., in the case of the DES paper, could the authors have used MCS or ABM? If not, why not?

This is an academic essay. I expect you to use normal academic references to justify your statements. Don't forget to reference your two chosen papers as well! Marks will be awarded for demonstrating understanding of the techniques and where they can and cannot be

applied. Part a) is worth a lot less than part b), so focus your efforts accordingly and do not waste precious words summarising the paper, describing the problem in detail, or presenting the model results and/or recommendations.

Note: Your chosen papers MUST have a proper journal reference. Web links, newspaper or magazine articles, unpublished working papers and other online documents are not allowed and will not count. You can include journal papers published electronically with a DOI date of 2022. You should use an academic electronic bibliographic search tool such as Google Scholar or Web of Knowledge. Please don't use normal Google as you are likely to end up with an ineligible paper. If you are in any doubt about whether a paper is eligible, please email it to me (joe.viana@bi.no) and I will confirm. **Please note that a flat penalty of 15% will be deducted from your final mark, for Part C, if one or both of your papers is ineligible.**

Grading criteria

Criteria	**Marks**
Description of features of the problem which in your view influenced the choice of technique	20
Discussion of whether it would have been possible to use the other approach for that problem	40
Use of literature to back up arguments	15
Language quality	15
Essay structure and overall presentation	10
	100