University of Wollongong

School of Business

BALA301 – Assessment 2

This is an individual assessment focused on Monte Carlo simulation and mathematical optimisation.

Case study:

You have been hired as a business analyst at a hospital that operates elective surgery rooms and employs a team of specialist surgeons. Each specialist regularly performs surgeries and requests operating room (OR) time each day. However, the actual time required varies from day to day and follows a known probability distribution, based on historical data.

Currently, the Operating Rooms Manager manually allocates specialists to ORs each day, with no restriction on overtime. While this allows flexibility, it often leads to imbalanced overtime across rooms, placing pressure on staff schedules and equipment availability. Prolonged overtime can result in staff fatigue, delays in instrument turnaround, and increased operating costs. To address these challenges, the hospital is evaluating several overtime policy options, each defining a different maximum allowable overtime per room. Your role as an analyst is to assess the operational and financial impacts of these policies using simulation and optimisation techniques, and to provide evidence-based recommendations on which policy should be adopted.

Operating room setup is as follows:

- The hospital has 4 operating rooms, labelled O1 to O4.
- There are 10 specialists, labelled S1 to S10.
- Each specialist must be assigned to exactly one operating room.
- Each operating room can be assigned to at most 3 specialists.
- Due to equipment conflicts:
    - S2 and S7 cannot be assigned to the same operating room.
    - S4 and S5 cannot be assigned to the same operating room.
- The daily time requirement for each specialist is uncertain but follows a *normal* probability distribution, estimated from historical data (see Table 1).
- Each operating room is available for 12 hours of regular time per day. Additional hours of overtime are also available if needed. The costs of regular time and overtime vary by room, based on the required equipment and staffing (see Table 2).
- The regular time cost for each operating room is incurred in full (for 12 hours), regardless of how much is actually used. Only overtime cost depends on the actual hours of excess usage.

Your role as the new analyst is to help design these long-term policies. In particular, the manager requires you to perform the following analysis:

Part A: Formulate the problem as a mixed-integer linear program (MILP). Your decision is to assign each specialist to one of the available operating rooms, with the objective of minimising the total daily cost of running the operating rooms, including both regular and overtime costs. You are also provided with three candidate long-term policies, each defined by the maximum allowable overtime per operating room per day. These policies reflect different levels of flexibility the hospital may be willing to tolerate:

- Policy 1: Maximum overtime per room = 3 hours
- Policy 2: Maximum overtime per room = 5 hours
- Policy 3: Maximum overtime per room = 7 hours

Run your optimisation model for 500 simulated days under each of the three policies. For each day, simulate the required OR time for all specialists using the provided probability distributions. Solve the model using Gurobi and record the following outputs:

- Daily total cost (based on regular and overtime usage)
- Overtime incurred in each operating room

After completing the simulation, compare the three policies in terms of average total cost, distribution of overtime, and room utilization balance. Recommend which policy the hospital should adopt.

Part B: In addition to comparing the three policies, the Operating Rooms Manager has raised two strategic questions. You are expected to simulate and evaluate the impact of each of the following constraints:

- Scenario 1: operating room O3 was not allowed to incur any overtime.
- Scenario 2: specialist S4 can only be assigned to OR3 or OR4.
- Scenario 3: specialist S4 is assigned to the same operating room every day.

For each scenario, re-run the simulation using the best-performing policy identified in Part A. Compare the results against the baseline to assess the operational and financial impact of each constraint.

Specialist	Mean Daily Time (hours)	Standard Deviation (hours)
S1	7.3	1.0
S2	4.0	0.6
S3	6.0	1.2
S4	7.5	1.5
S5	5.0	0.8
S6	6.8	1.3
S7	3.5	1.0
S8	7.0	1.1
S9	6.5	1.0
S10	5.5	1.4

Table 1: Specialist time distributions.

Operating Room	Regular Time Cost (monetary units)	Overtime Cost (monetary units)
O1	33	50
O2	28	45
O3	35	52
O4	30	47

Table 2: Operating room cost parameters.