Optimisation Case Study - Staff Planning: Submitted by Perinkumar Patel and Payal Mehta Shah Problem Statement

An insurance company wants to find the optimal number of staff that they need for their insurance application approval process for the calendar year 2021.

1. The company operates in three states: A, B and C. The state-wise demand for insurance for the year is given for each month
2. The company can either handle an application with the staff that they hire or outsource it to a vendor.
3. A staff member's availability (in percentage) for each month is also provided.
4. The regulatory constraints for each state is also provided.

The objective is to optimise the total cost for the application approval process by distributing the right number of applications between the FTEs and the vendors while meeting the monthly demand for each state at the same time.

Q1. The company wants to know the optimised staffing recommendations for the business case described. Write the mathematical model for the deterministic optimisation problem. Define and explain your decision variables, objective function and the constraint.

Decision Variables:

- x(i,j): This continuous variable indicates the number of FTE serving the state 'i' in month j.
- y(i,j): This discrete variable indicates the number of outsourced applications for the state 'i' in month j.

Objective function:

1. We have to multiply the FTE each month by the salary and availability to get the cost of applications for FTE, i.e. X multiplied by FTE_salary multiplied by Staff_Avl

2. To get the outsourced cost, we have to multiply number of applications outsourced with the outsourcing cost, i.e. Y multiplied by Unit_cost
3. Correspondingly our objective function is to minimise the sum of the two costs above, i.e.
4. Cost Function: Minimise ∑∑ x(i,j)*FTE_Salary(i,j) * Staff_Avl(i,j) + ∑∑ y(i,j) * Unit_cost(i,j)]

Constraints:

1. Demand Constraint: The number of applications processed by FTE and the by Outsourced should be equal to the total demand for each month, i.e. x(i,j) * Staff_Avl(i,j) + y(i,j) = Demand(i,j) Regulation Constraints: The outsourced applications should not be more that the specified regulations.
2. For State A, y(i,j)<=Demand(i,j) X 30%
3. For State B, y(i,j)<=Demand(i,j) X 40%
4. Variable type - x(i,j) should be a continuous (+ve, real) number - y(i,) should be a non-negative integer

Parameters:

The following are the major parameters :

1. Demand(i,j) which is the demand for each state for a particular month
2. Staff_Availability(i,j): Staff Availability, i.e. the % availability of the full time employees each month
3. Fulltimeemployee_Salary(i,j): Salary of FTE for each state per month
4. Outsourcing Cost or Unit_cost(i,j): The cost of outsourcing per state each month
5. The maximum applications served by each FTE per month (FTE_serve_rate = 40/month)

Q2. Code the problem in Python using any optimisation package of your choice.

- Code provided in the attached Jupyter Notebook.

Q.3 The company also wants to know the staffing recommendations for the worst-case and best-case scenarios. As mentioned earlier, there are days that an employee will be unavailable to process applications due to training, off days, etc. This will affect employee availability.

What is the optimal number of staff members for the worst and best cases?

Worst Case: The following DataFrame (also provided in the Jupyter Notebook) shows the optimal staff members for worst case Scenario.

```
df_1.head(11)
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	StateMonth	FTE	StaffAvaibility	OutSourced_Application	Demand	application_serve	application_outsource	Staff_Application	State	Month
0	(A, Jan)	187.14	0.81	0.0	5240	6063.0	-823.0	5240.0	A	Jan
1	(A, Feb)	131.35	0.76	1463.0	4878	3993.0	885.0	3415.0	A	Feb
2	(A, Mar)	212.21	0.75	0.0	5942	6366.0	-424.0	5942.0	A	Mar
3	(A, Apr)	76.57	0.80	0.0	2297	2450.0	-153.0	2297.0	A	Apr
4	(A, May)	71.14	0.78	0.0	1992	2220.0	-228.0	1992.0	A	May
5	(A, Jun)	61.27	0.73	682.0	2275	1789.0	486.0	1593.0	A	Jun
6	(A, Jul)	155.58	0.68	1600.0	5334	4232.0	1102.0	3734.0	A	Jul
7	(A, Aug)	90.77	0.76	1011.0	3371	2759.0	612.0	2360.0	A	Aug
8	(A, Sep)	134.25	0.81	0.0	3759	4350.0	-591.0	3759.0	A	Sep
9	(A, Oct)	95.04	0.73	1058.0	3529	2775.0	754.0	2471.0	A	Oct
10	(A, Nov)	124.96	0.68	1285.0	4284	3399.0	885.0	2999.0	A	Nov

Best Case: The following DataFrame (also provided in the Jupyter Notebook) shows the optimal staff members for best case scenario.

```
df_2
```

	StateMonth	FTE	StaffAvaibility	Out_Sourced	Demand	application_serve	application_outsource
0	(A, Jan)	145.56	0.81	0.0	5240	4716.0	524.0
1	(A, Feb)	143.47	0.76	0.0	4878	4361.0	517.0
2	(A, Mar)	185.69	0.75	0.0	5942	5571.0	371.0
3	(A, Apr)	67.56	0.80	0.0	2297	2162.0	135.0
4	(A, May)	58.59	0.78	0.0	1992	1828.0	164.0
5	(A, Jun)	71.09	0.73	0.0	2275	2076.0	199.0
6	(A, Jul)	177.80	0.68	0.0	5334	4836.0	498.0
7	(A, Aug)	99.15	0.76	0.0	3371	3014.0	357.0
8	(A, Sep)	104.42	0.81	0.0	3759	3383.0	376.0
9	(A, Oct)	110.28	0.73	0.0	3529	3220.0	309.0
10	(A, Nov)	142.80	0.68	0.0	4284	3884.0	400.0
11	(A, Dec)	185.11	0.65	0.0	5183	4813.0	370.0

What are the percentages of outsourcing and average cost per application for the worst and best cases?

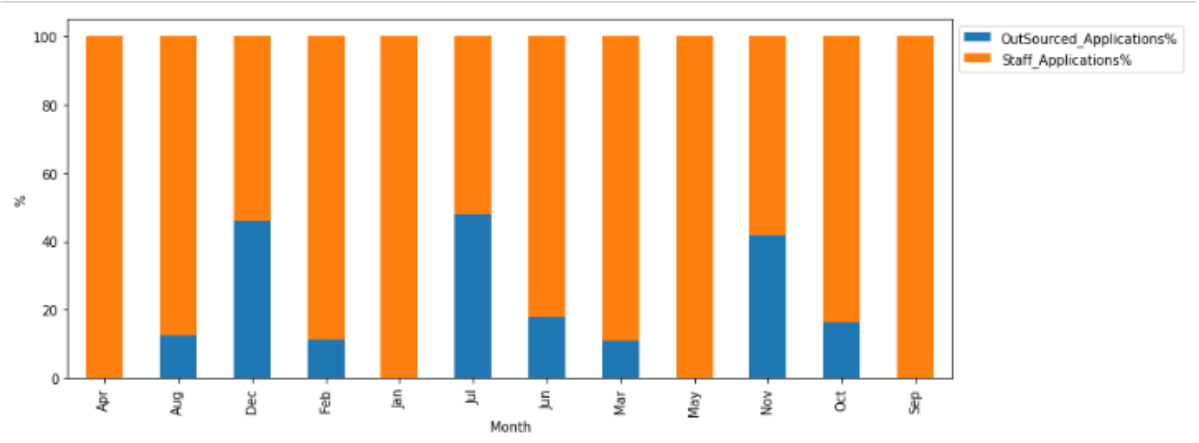
1. The overall outsourced application in the worst case scenario is 31.4%.
2. The overall outsourced application in the best case scenario is 3.1%. The monthly state wise split is also provided in the Jupyter notebook.
3. The Average Cost per Application in the worst case is 173.91
4. The Average Cost per Application in the best case is 145.95 The monthly averages are also provided in the Jupyter notebook.

Q.4 Create the following visualisations using your preferred method (i.e. Python, PowerPoint, Excel, etc.) and add it to your report.

Use the solution of Q2 to create a stacked column chart that shows the percentage of applications processed by the staff and by the vendor for each month (%staff processed applications + %vendor processed applications should add up to 100%).

Create a graph to show how the cost per application increases with respect to any change in the parameters in your analysis. (Hint: Use the cost per application that you calculate in Questions 2 and 3, i.e., the actual scenario, best case, and worst case.)

Percentage of applications processed by the staff and by the vendor for each month



December, July and November had the highest proportion of outsourced applications. January ,April and September are likely to have almost no requirement of outsourcing.

Trend of Cost/Application w.r.t. to any change in the parameters (Likely vs BestCase vs WorstCase)