Staff Planning Case Study

Problem Introduction

The insurance approval process, i.e., underwriting is one of the important and time-consuming tasks in an insurance application processing. When you submit your insurance application, the underwriter of the company evaluates it based on the details that you provide using a rule-based or an ML model and decides whether or not to approve your application. You can refer to this link for a better understanding of the underwriting process though it is not pertinent to the case study.

An insurance company InsurePlus wants you to help them with finding the optimal number of staff that they need for their insurance application approval process for the calendar year 2021. In the industry, the number of staffs is considered as a continuous variable. This is also called a Full-Time Equivalent (FTE) of the staff. For example, if a full-time employee (FTE =1) works for 50 hours a week, 10 hours corresponds to 0.2 FTEs. If the pay for 50 hours a week is $5000, then 0.2 FTE who may be a part-time employee will be paid $1000 (5000*0.2). You can read about the concept of a full-time equivalent here. In this case study, you have been provided with the information that follows.

Note: Go through each and every point carefully to not miss out on any information.

Problem statement & background

- The company operates in three states: A, B and C. The state-wise demand for insurance for the year is shown in the table provided below:

States	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	5240	4878	5942	2297	1992	2275	5334	3371	3759	3529	4284	5183
B	4927	2628	2974	2338	4020	3147	4271	2620	4517	4155	3137	4227
C	1162	1967	1898	2261	2030	1642	2489	2496	922	2421	963	1998

- The company can either handle an application with the staff that they hire or outsource it to a vendor. Assume that there is no capacity limitation to outsourcing.
- If they hire staff, he/she can handle 40 insurance applications per month when he/she works 100% of the workdays. However, there are days that he/she will be unavailable to process applications due to training, off days, etc.
- A staff member's availability (in percentage) to work on processing the insurance applications for each month is shown in the table given below. As mentioned before, with 100% availability, each member can handle 40 applications.

States	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	81%	76%	75%	80%	78%	73%	68%	76%	81%	73%	68%	65%
B	81%	76%	75%	80%	78%	73%	68%	76%	81%	73%	68%	65%
C	81%	76%	75%	80%	78%	73%	68%	76%	81%	73%	68%	65%

A special note of practical relevance: In the industry, staff availability is predicted using a time-motion study. But in this case, you have been given fixed numbers for each month in the table above. You can read more about the time-motion study here if you are curious but please note that it is not required to solve the case study.

- States A and B have a regulatory restriction that the outsourced insurance applications cannot be more than 30% and 40% of the total number of applications for each month, respectively.
- The table given below shows the cost of the staff vs external resources:

State	Annual Salary of Staff	Outsourcing Cost per Application
A	$60,000	$180
B	$55,000	$150
C	$53,000	$160

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.

Question 1

The company wants to know the optimised staffing recommendations for the business case described. Write the mathematical model for the deterministic optimization problem. Define and explain your decision variables, objective function and the constraint. (Hint: Use months of the year as the model timeline).

InsurePlus wants to optimise the cost for staffing plan so we derive following mathematical model

Data given:

1) Locations: A, B, C
2) Demand data provided for state wise and month wise
3) Resources: Full Time Employees, Outsourced Application
4) Staff Availability state wise and month wise
5) Staff Annual Salary state wise state wise and month wise
6) Outsource Cost per application state wise and month wise
7) Outsourcing restriction at state A & B @ 30% & 40% respectively

Mathematical Model:

Index:

i=*State*
j=*Month*

Parameters:

Demand = $Demand(i,j)$
Staff Availability Percentage = $StaffAv(i,j)$
FTESalary = $FTESalary(i,j)$
Unit Outsource Cost = UnitCost(i,j)

FTEAppServeRate = $(No.ofAppl/Month)$

Decision Variables:

$FTEEquivallentatanylocation,month(ContinuousVar)=X(i,j)$

$OutSourceAppQtyinamonth(Integer)=Y(i,j)$

Objective Function:

$MinimizeCost=AnnualTotalCostofFTE+AnnualTotalCostofOutsourcedApplication$

$\sum_i\sum_j FTESalary(i,j)*X(i,j)+\sum_i\sum_j UnitCost(i,j)*Y(i,j) >= C_{min}$

Question 2

Code the problem in Python and use any optimization package to solve it. Add comments to your code to explain each step.

Expected output:

Create a data frame containing the number of outsourced applications and the number of FTEs for each state-month combination. You can choose to have extra columns like staff availability, demand etc. in your dataframe apart from the ones mentioned earlier.

Solution.

```
# ==========================================================
# = Solver Results                                         =
# ==========================================================
# ----------------------------------------------------------
#   Problem Information
# ----------------------------------------------------------
Problem:
- Name: unknown
  Lower bound: 17962336.4487699
  Upper bound: 17962336.4487699
  Number of objectives: 1
  Number of constraints: 61
  Number of variables: 73
  Number of nonzeros: 97
  Sense: minimize
# ----------------------------------------------------------
#   Solver Information
# ----------------------------------------------------------
Solver:
- Status: ok
  Termination condition: optimal
  Statistics:
    Branch and bound:
      Number of bounded subproblems: 0
      Number of created subproblems: 0
  Error rc: 0
  Time: 0.20194578170776367
# ----------------------------------------------------------
#   Solution Information
# ----------------------------------------------------------
Solution:
- number of solutions: 0
  number of solutions displayed: 0
```

	State	Month	FTE	App_Outsourced
0	A	Jan	161.728395	0.0
1	A	Feb	160.460526	0.0
2	A	Mar	198.066667	0.0
3	A	Apr	71.781250	0.0
4	A	May	63.846154	0.0

Question 3

Worst-case and best-case analysis based on the staffs' availability.

Assuming that the distribution is the same across all the states,

3.1 Worst case analysis

- 3.1.1 What is the optimal number of staff members for the worst case?
- 3.1.2 What is the percentage of outsourcing for the worst case?
- 3.1.3 What is the average cost per application for the worst case?

3.2 Best case analysis

- 3.2.1 What is the optimal number of staff members for the best case?
- 3.2.2 What is the percentage of outsourcing for the best case?
- 3.2.3 What is the average cost per application for the best case?

3.1 Worst Case Analysis

3.1.1 Optimal number of staff members

	State	Month	FTE	App_Outsourced
0	A	Jan	187.142857	0.0
1	A	Feb	131.346154	1463.0
2	A	Mar	212.214286	0.0
3	A	Apr	76.566667	0.0
4	A	May	71.142857	0.0

3.1.2 Percentage of outsourced applications

3.1.2 Percentage of outsourced applications

In [128]:
```
# write your code here

TotlAppDemand = MgDemandDist['Demand'].sum()
TotlAppDemand

PercentageOutsourced = ((FTE_StaffWC['App_Outsourced'].sum() / TotlAppDemand)* 100).round(2)
PercentageOutsourced
```

Out[128]: 35.14

3.1.3 Average cost per application

```
# write your code here

TotalFTEWC = FTE_StaffWC['FTE'].sum()
AverageFTEPerMonthWC = (TotalFTEWC/12).round(2)
print(AverageFTEPerMonthWC)

AverageCostPerApplWC = (TotalCostWC / TotlAppDemand).round(2)
print(AverageCostPerApplWC)
```

```
230.11
173.0
```

3.2 Best Case Analysis

3.2.1 Optimal number of staff members

	State	Month	FTE	App_Outsourced
0	A	Jan	145.555556	0.0
1	A	Feb	143.470588	0.0
2	A	Mar	185.687500	0.0
3	A	Apr	67.558824	0.0
4	A	May	58.588235	0.0

3.2.2 Percentage of outsourced applications

```
# write your code here

TotlAppDemand = MgDemandDist['Demand'].sum()
TotlAppDemand

PercentageOutsourcedBC = ((FTE_StaffBC['App_Outsourced'].sum() / TotlAppDemand)* 100).round(2)
PercentageOutsourcedBC
```

```
4.11
```

3.2.3 Average cost per application

```
# write your code here

TotalFTEBC = FTE_StaffBC['FTE'].sum()
AverageFTEPerMonthBC = (TotalFTEBC/12).round(2)
print(AverageFTEPerMonthBC)

AverageCostPerApplBC = (TotalCostBC / TotlAppDemand).round(2)
print(AverageCostPerApplBC)
```

```
278.6
145.88
```

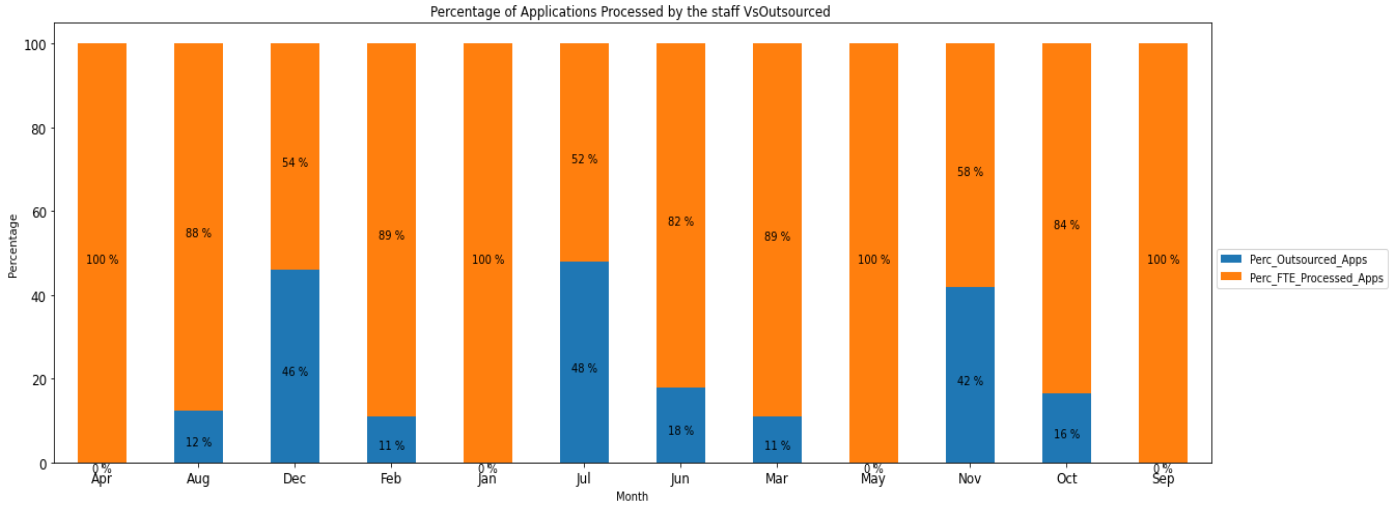
Question 4

Creating Visualisations

Create the following visualisations using your preferred method (i.e. Python, PowerPoint, Power BI, 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 best case, and the worst case).

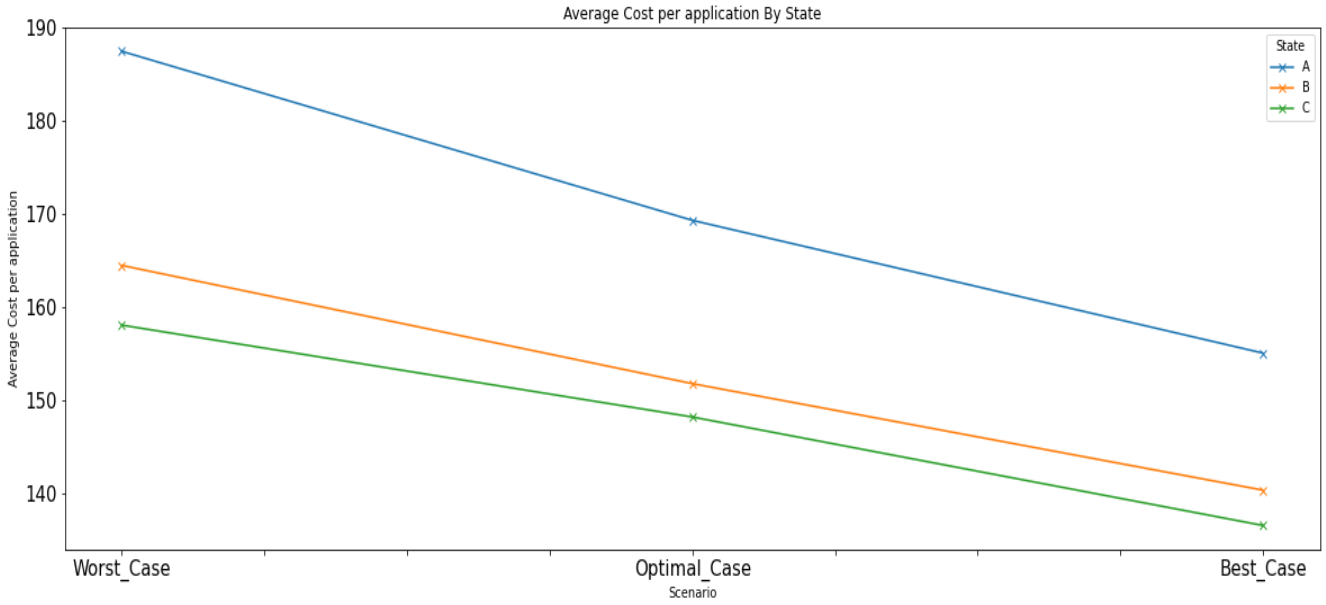
Percentage of applications processed for each month in different scenarios: (Month-wise Combined Analysis)



Month-Wise analysis Inferences–
• % of staff processed applications + % of vendor processed applications added up to 100%.
• More than 40% outsourcing to vendors is required during the months of July, November and December.
• No Outsourcing is required for January, April, May and September and 100% applications can be processed by the internal staff.
• February, March and August have the lowest % of outsourcing to vendors.

4.2) Average cost per application for each state in different scenarios: (State-Wise Combined Analysis)

State	Worst_Case	Optimal_Case	Best_Case
A	187.48	169.34	155.09
B	164.50	151.81	140.38
C	158.09	148.23	136.59



State-Wise analysis Inferences:

- As expected, the Average cost per Application by state is highest in worst case scenario followed by optimal case and lowest in Best Case.
- The average Cost per application is higher for state A, in all scenarios, as compared to States B and C