

Staff Planning Case Study



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Problem Statement

- An insurance company InsurePlus wants help with finding the optimal number of staff that they need for their insurance application approval process for the calendar year 2021.
- The company operates in three states: A, B and C.
- The company can either handle an application with the staff that they hire or outsource it to a vendor. There is no capacity limitation to outsourcing.

Objective of the Case Study:

To optimize 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.



State-Wise Monthly Demand for Insurance

The table given below shows the **state-wise monthly demand for insurance for the year**

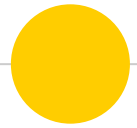
State	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	5240	4878	5942	2297	1992	2275	5334	3371	3759	3529	4284	5183
B	4927	2628	2974	2338	4020	3147	4271	2620	4517	4155	3137	4227
C	1162	1967	1898	2261	2030	1642	2489	2496	922	2421	963	1998



State-Wise Cost of the Staff and the Vendor

The table given below shows the **cost of the staff vs the external resources**

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



Solutions for the Given Problem



Mathematical Formulations

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.

Ans: Mathematical Model of the problem statement :

- **Indexes –**

The variables and parameters for the given problem vary with location of the company and month. Hence, the indexes are as follows:

- i. Insurance Company Location: $i \in \text{InsCom_Location}$
- ii. Month: $j \in \text{Month}$

Thus, 'i' is an element of the set 'InsCom_Location' and 'j' is an element in set 'Month'.



Mathematical Formulations

- **Parameters** – Following are the parameters for the given problem:
 - i. Demand for insurance for the year per Location per Month - $d(i,j)$
 - ii. Full Time Equivalent (FTE) salary per Location per month for 2021 - $fs(i,j)$
 - iii. Outsourcing cost per application per location per month - $osc(i,j)$
 - iv. Staff Availability Percentage per location per month - $sap(i,j)$
 - v. FTE application serving rate per month when 100% working (fsr) i.e., $FTE_AppServiceRate = 40$
- **Decision Variables** –
 - i. Staff FTE per location per month - $x(i,j)$
 - ii. Number of application outsourced per location per month - $y(i,j)$



Mathematical Formulations

- **Constraints**

- **Demand Constraint**

The combined total number of applications processed by the full-time employees and outsourced resources should be equal to the demand per month at each location :

$$[x(i,j) * \text{FTE_AppServiceRate} * \text{sap}(i,j)] + y(i,j) = d(i,j) , \forall i,j$$

- **Regulatory Constraints**

Locations A & B have regulatory constraints which state that the outsourced insurance applications cannot be more than 30% and 40% of the total number of applications for each month, respectively.

- i. $y(i, j) \leq d(i,j) * 0.3 , \forall i = 'A' , j \in \text{Month}$

- ii. $y(i, j) \leq d(i,j) * 0.4 , \forall i = 'B' , j \in \text{Month}$

- **Integer Constraint**

Number of application outsourced per location per month $y(i,j)$ should be '**Non-Negative Integer**'

- **Continuous Constraint**

Staff FTE per location per month should be continuous (Non-Negative Real) variable: $x(i,j) \geq 0$

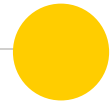


Mathematical Formulations

- **Objective Function**

The objective is to minimize the annual cost spent on full time employees + annual cost of outsourcing applications.

$$\text{Minimize } (\sum_i \sum_j x(i,j) * fs(i,j) + \sum_i \sum_j osc(i,j) * y(i,j))$$



Actual Case Results

- In actual scenario, consider the below staff availability each month at each location.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
StaffAvPer	0.81	0.76	0.75	0.80	0.78	0.73	0.68	0.76	0.81	0.73	0.68	0.65

- The solver results for decision variables i.e., Staff_FTE and App_Outsourced are stored in 'FTE_Staff' dataframe.
- Estimated Cost Per Month column contains the total application processing cost (in \$) for the respective month and state.
- Cost Per Application column contains the processing cost (in \$) for each application.
- Here is an image of the top 10 data rows of 'FTE_Staff' dataframe.

	State	Month	Demand	Staff_FTE	App_Outsourced	Estimated Cost Per Month	Cost Per Application
0	A	Jan	5240	161.728395	0.0	808641.975309	154.32
1	A	Feb	4878	160.460526	0.0	802302.631579	164.47
2	A	Mar	5942	198.066667	0.0	990333.333333	166.67
3	A	Apr	2297	71.781250	0.0	358906.250000	156.25
4	A	May	1992	63.846154	0.0	319230.769231	160.26
5	A	Jun	2275	77.910959	0.0	389554.794521	171.23
6	A	Jul	5334	137.279412	1600.0	974397.058824	182.68
7	A	Aug	3371	110.888158	0.0	554440.789474	164.47
8	A	Sep	3759	116.018519	0.0	580092.592593	154.32
9	A	Oct	3529	120.856164	0.0	604280.821918	171.23

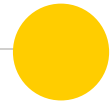


Actual Case Analysis Based on the Staffs' Availability

Actual Case Analysis

- What is the optimal number of staff members for the actual case?
Ans: 3085.5 is the optimal number of staff members for the actual case.
- What is the percentage of outsourcing for the actual case?
Ans: 18.31% is the percentage of outsourcing for the actual case.
- What is the average cost per application for the actual case?
Ans: \$155.88 is the average cost per application for the actual case.

The company has to spend around 17.9 m\$ in total for the application approval process.



Worst Case Results

- In worst scenario, consider the below staff availability each month at each location.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LB	0.70	0.65	0.70	0.75	0.70	0.65	0.60	0.65	0.70	0.65	0.60	0.60

- The solver results for decision variables i.e., Staff_FTE and App_Outsourced are stored in 'FTE_Staff_Worst' dataframe.
- Estimated Cost Per Month column contains the total application processing cost (in \$) for the respective month and state.
- Cost Per Application column contains the processing cost (in \$) for each application.
- Here is an image of the top 10 data rows of 'FTE_Staff_Worst' dataframe.

	State	Month	Demand	Staff_FTE	App_Outsourced	Estimated Cost Per Month	Cost Per Application
0	A	Jan	5240	187.142857	0.0	9.357143e+05	178.57
1	A	Feb	4878	131.346154	1463.0	9.200708e+05	188.62
2	A	Mar	5942	212.214286	0.0	1.061071e+06	178.57
3	A	Apr	2297	76.566667	0.0	3.828333e+05	166.67
4	A	May	1992	71.142857	0.0	3.557143e+05	178.57
5	A	Jun	2275	61.269231	682.0	4.291062e+05	188.62
6	A	Jul	5334	155.583333	1600.0	1.065917e+06	199.83
7	A	Aug	3371	90.769231	1011.0	6.358262e+05	188.62
8	A	Sep	3759	134.250000	0.0	6.712500e+05	178.57
9	A	Oct	3529	95.038462	1058.0	6.656323e+05	188.62



Worst-Case Analysis Based on the Staffs' Availability

Q3. 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?

Ans: 2761.27 is the optimal number of staff members for the worst case.

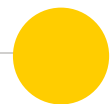
- 3.1.2 What is the percentage of outsourcing for the worst case?

Ans: 35.14% is the percentage of outsourcing for the worst case.

- 3.1.3 What is the average cost per application for the worst case?

Ans: \$169.57 is the average cost per application for the worst case

The company has to spend around 19.6 m\$ in total for the application approval process if the staffs are working with the minimum availability.



Best Case Results

- In best scenario, consider the below staff availability each month at each location.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
UB	0.90	0.85	0.80	0.85	0.85	0.80	0.75	0.85	0.90	0.80	0.75	0.70

- The solver results for decision variables i.e., Staff_FTE and App_Outsourced are stored in 'FTE_Staff_Best' dataframe.
- Estimated Cost Per Month column contains the total application processing cost (in \$) for the respective month and state.
- Cost Per Application column contains the processing cost (in \$) for each application.
- Here is an image of the top 10 data rows of 'FTE_Staff_Best' dataframe.

	State	Month	Demand	Staff_FTE	App_Outsourced	Estimated Cost Per Month	Cost Per Application
0	A	Jan	5240	145.555556	0.0	727777.777778	138.89
1	A	Feb	4878	143.470588	0.0	717352.941176	147.06
2	A	Mar	5942	185.687500	0.0	928437.500000	156.25
3	A	Apr	2297	67.558824	0.0	337794.117647	147.06
4	A	May	1992	58.588235	0.0	292941.176471	147.06
5	A	Jun	2275	71.093750	0.0	355468.750000	156.25
6	A	Jul	5334	177.800000	0.0	889000.000000	166.67
7	A	Aug	3371	99.147059	0.0	495735.294118	147.06
8	A	Sep	3759	104.416667	0.0	522083.333333	138.89
9	A	Oct	3529	110.281250	0.0	551406.250000	156.25



Best-Case Analysis Based on the Staffs' Availability

3.2 Best Case Analysis

- **3.2.1** What is the optimal number of staff members for the best case?

Ans: 3343.19 is the optimal number of staff members for the best case.

- **3.2.2** What is the percentage of outsourcing for the best case?

Ans: 4.11% is the percentage of outsourcing for the best case.

- **3.2.3** What is the average cost per application for the best case?

Ans: \$143.42 is the average cost per application for the best case.

The company has to spend around 16.5 m\$ in total for the application approval process if the staffs are working with the maximum availability.



Comparison of Results of Each Scenario

Scenario	Optimal Number of Staff Members	Percentage of Outsourcing	Average Cost Per Application
Best	3343.19	4.11%	\$143.42
Actual	3085.5	18.31%	\$155.88
Worst	2761.27	35.14%	\$169.57

Insights –

- Staff availability is highest in best scenario and least in worst scenario. This can be confirmed by the decreasing number of staff members in the above table.
- When there is decrease in staff availability, more applications need to be processed by vendor. Thus, there is an increase in the percentage of outsourcing.
- When the outsourcing increases, the average cost per application increases.



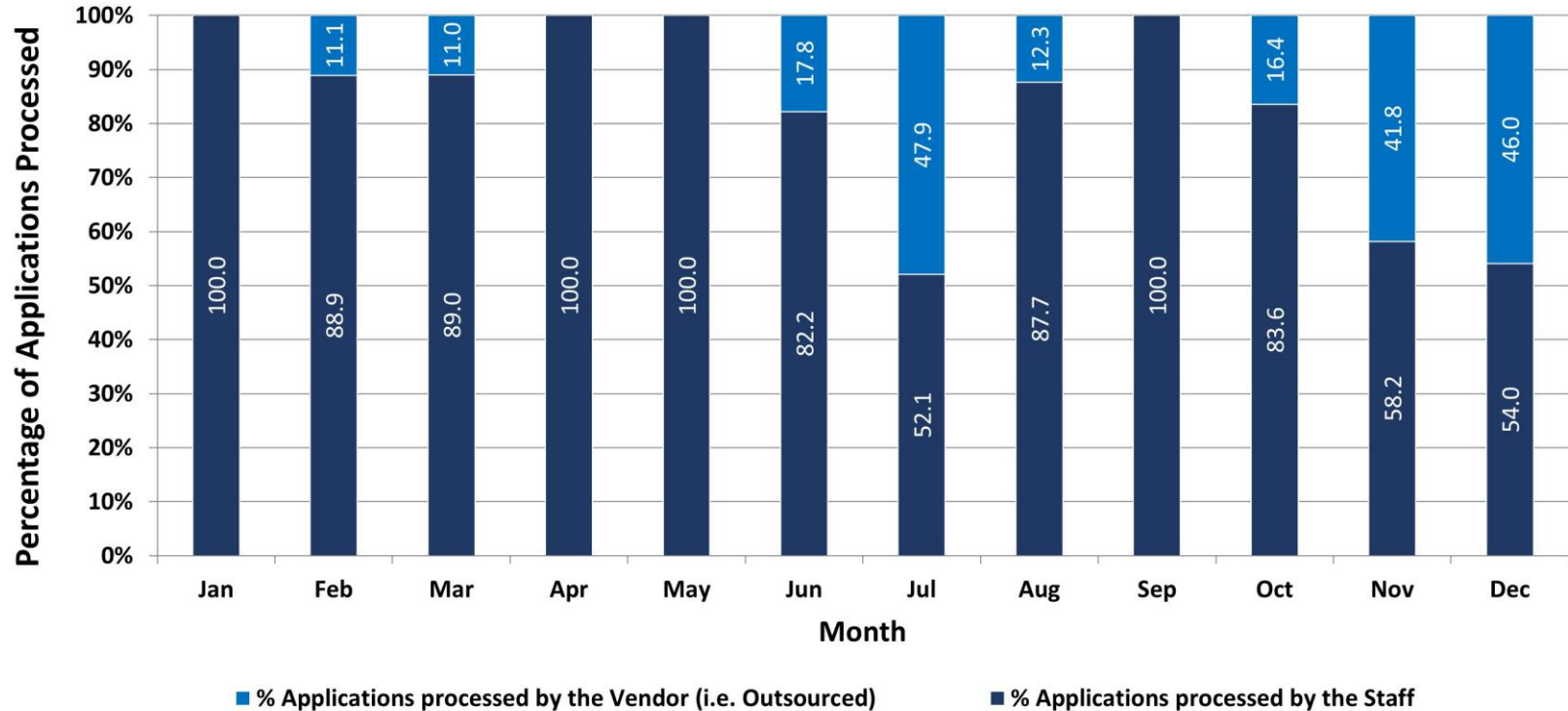
Visualizations

Q4.

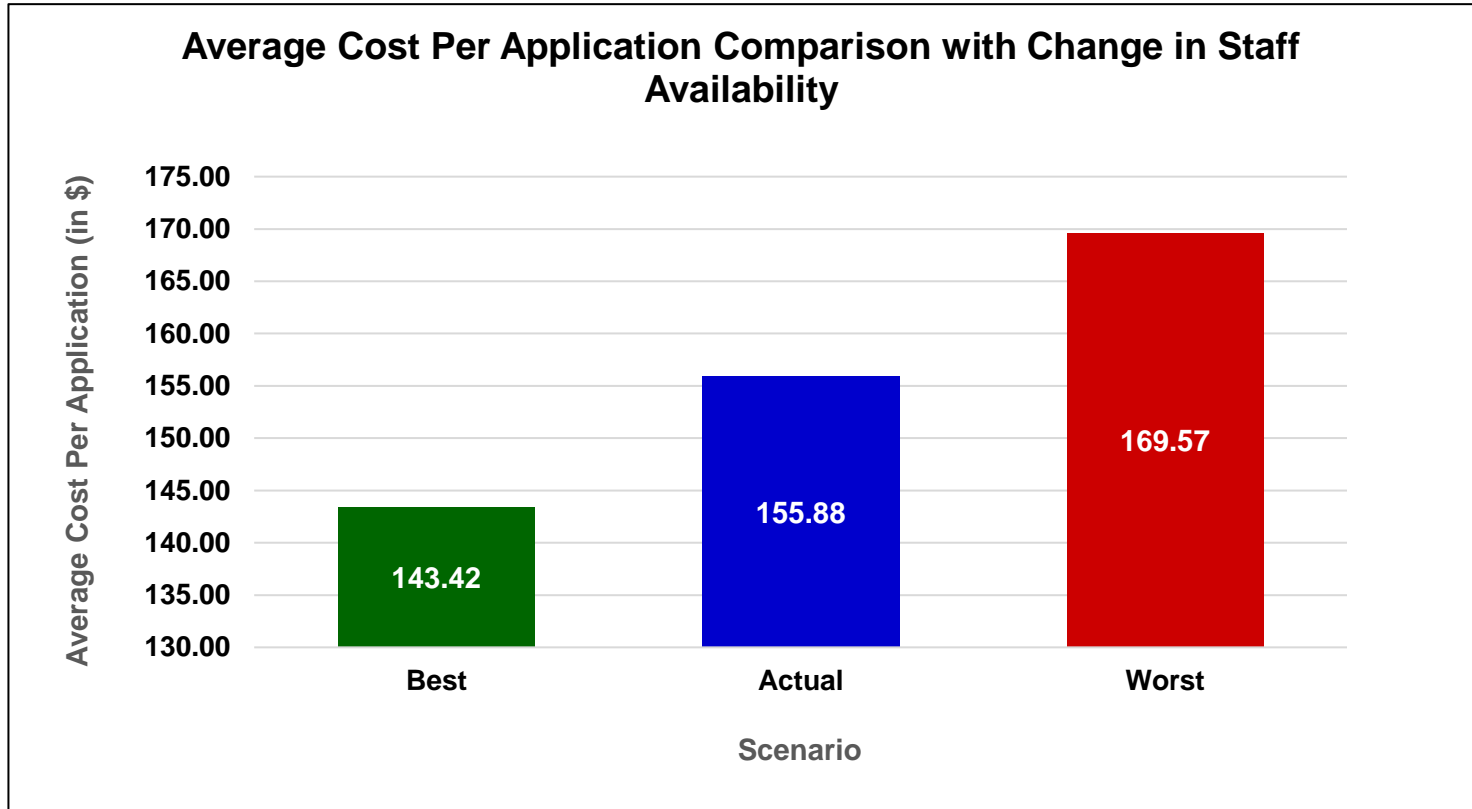
- a. Use the solution of Q2 to create a stacked column chart that shows the percentage of applications processed by the staff and by the vendor for each month (%staff processed applications+ %vendor processed applications should add up to 100%).
- b. Create a graph to show how the cost per application 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).

Q4 a

Overall Percentage of Applications Processed by the Staff and Vendor (i.e. Outsourced)

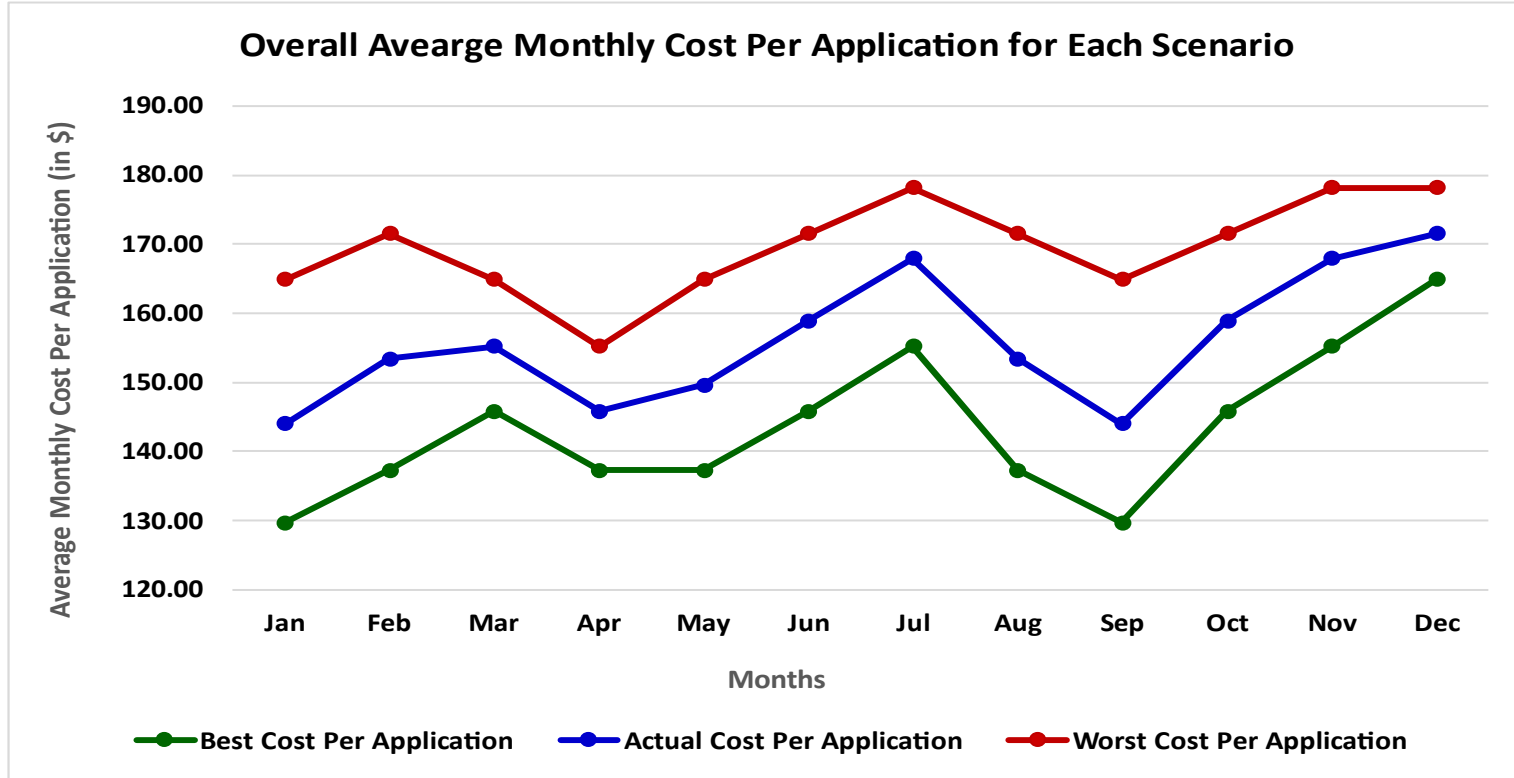


Q4 b



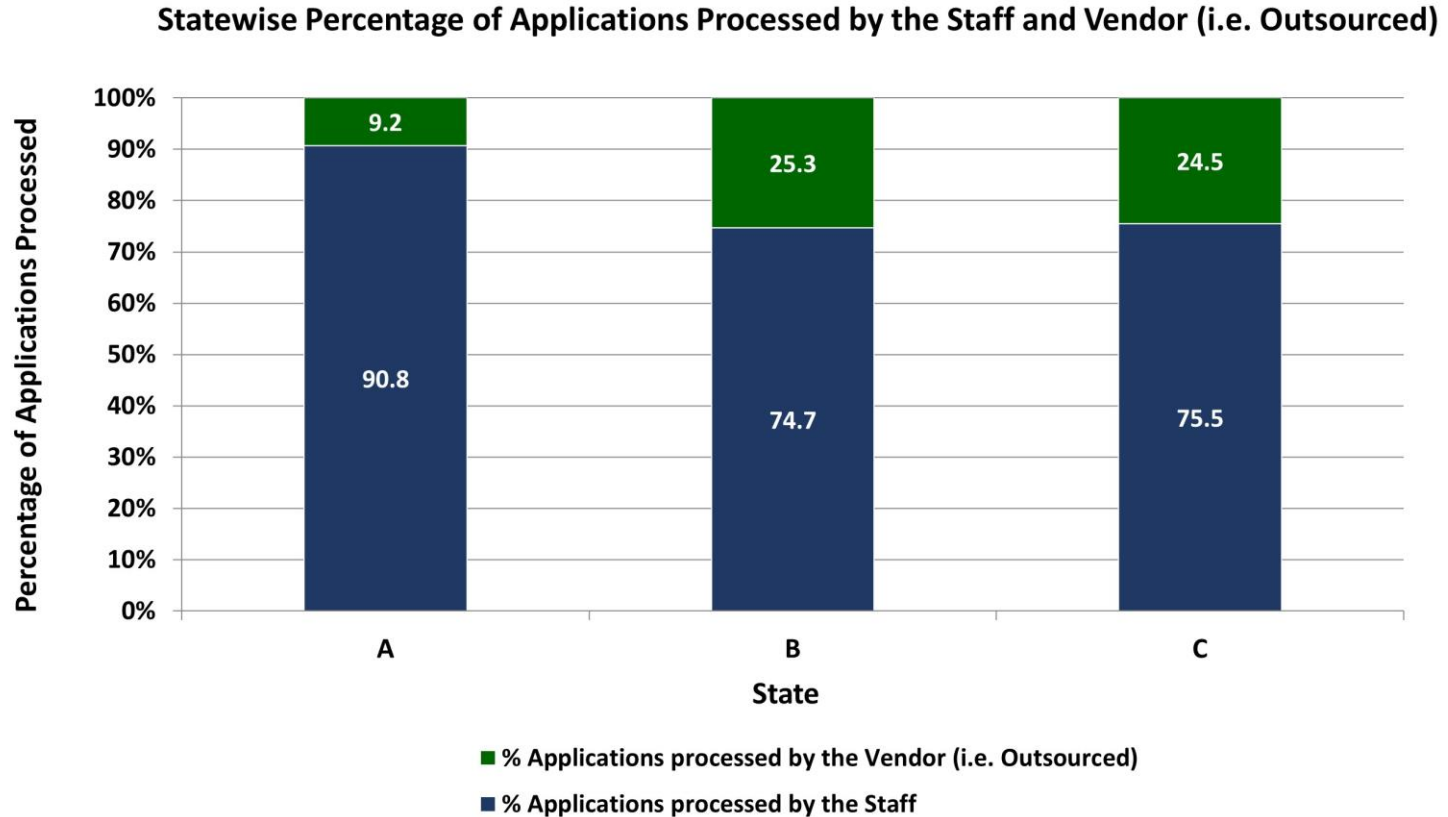
c

Other Visualizations



d

Other Visualizations





Key Insights

- For the months of January, April, May and September, the applications were processed completely by the Staff. (**Refer plot a**)
- For the months of July, November and December, the percentage of applications processed by the Vendor was more compared to the quantity in other months. (**Refer plot a**)
- At **location state A**, **least** percentage (**9.2%**) of applications have been **processed by vendor** (i.e. outsourced). **Refer plot d.**
- The average cost per application is the highest for worst case scenario i.e. **\$169.57** and lowest for best case scenario i.e. **\$143.42**. Therefore, the average cost per application increases with decrease in staff availability (**Refer plot b**). The variation in monthly cost per application can also be seen in plot c.