

OPTIMIZATION CASE STUDY

BUSINESS ANALYTICS, DS C17 BATCH 2

DECISION VARIABLES, OBJECTIVE FUNCTION, CONSTRAINTS

QUESTION 1

DECISION VARIABLES: Number of Full-Time Equivalents (FTE's) and Number of Outsourced Applications. In the model, it is termed as 'x' and 'y' respectively. When we have an additional vendor at the end, it is labelled as 'z'. Our objective will be to minimize the cost of the loan approval process by distributing the number of FTE's and outsourced applications.

OBJECTIVE FUNCTION: Minimize
$$\sum_{b \in B, m \in M} (Salary_{b,m} * x_{b,m} + Outsource\ Cost_{b,m} * y_{b,m})$$

where Salary is the salary of the employees in a state and Outsource Cost is the cost for vendors in that state, B is the Location (States A, B, C) and m is the Month.

CONSTRAINTS:

i) **Demand Constraint:** $x_{b,m} * \text{Staff Availability}_{b,m} * 40 + y_{b,m} = \text{Demand}_{b,m}$

ii) **Outsource Constraint:** a) $y_{b,m} \leq 0.3 \text{ Demand}_{b,m}$ for b = State A

b) $y_{b,m} \leq 0.4 \text{ Demand}_{b,m}$ for b = State B

Actual Scenario

State	Month	Full-Time Equivalents	Outsourced Applications
A	Jan	161.73	0
A	Feb	160.46	0
A	Mar	198.07	0
A	Apr	71.78	0
A	May	63.85	0
A	Jun	77.91	0
A	Jul	137.28	1600
A	Aug	110.89	0
A	Sep	116.02	0
A	Oct	120.86	0
A	Nov	110.26	1285
A	Dec	139.58	1554
B	Jan	152.07	0
B	Feb	51.88	1051
B	Mar	59.50	1189
B	Apr	73.06	0
B	May	128.85	0
B	Jun	64.69	1258
B	Jul	94.23	1708
B	Aug	51.71	1048
B	Sep	139.41	0
B	Oct	85.38	1662
B	Nov	69.23	1254
B	Dec	97.58	1690
C	Jan	35.86	0
C	Feb	64.70	0
C	Mar	63.27	0
C	Apr	70.66	0
C	May	65.06	0
C	Jun	56.23	0
C	Jul	0.00	2489
C	Aug	82.11	0
C	Sep	28.46	0
C	Oct	82.91	0
C	Nov	0.00	963
C	Dec	0.00	1998

- In the actual scenario, the company has to spend \$17.9 m in total for the application approval process

Note: We need to multiply the FTE's with 40 to get the number of applications processed by the staffs

10% Limit on Outsourcing

State	Month	Full-Time Equivalents	Outsourced Applications
A	Jan	161.73	0
A	Feb	160.46	0
A	Mar	198.07	0
A	Apr	71.78	0
A	May	63.85	0
A	Jun	77.91	0
A	Jul	176.51	533
A	Aug	110.89	0
A	Sep	116.02	0
A	Oct	120.86	0
A	Nov	141.76	428
A	Dec	179.42	518
B	Jan	152.07	0
B	Feb	77.83	262
B	Mar	89.23	297
B	Apr	73.06	0
B	May	128.85	0
B	Jun	97.02	314
B	Jul	141.32	427
B	Aug	77.57	262
B	Sep	139.41	0
B	Oct	128.08	415
B	Nov	103.82	313
B	Dec	146.35	422
C	Jan	35.86	0
C	Feb	64.70	0
C	Mar	63.27	0
C	Apr	70.66	0
C	May	65.06	0
C	Jun	56.23	0
C	Jul	82.39	248
C	Aug	82.11	0
C	Sep	28.46	0
C	Oct	82.91	0
C	Nov	31.88	96
C	Dec	69.19	199

- The company has to spend \$18.1 m when there is a 10% limit on outsourcing.
- Additional cost per application is \$1.22 compared to the actual scenario

Increasing Outsourcing Costs by 20%

State	Month	Full-Time Equivalents	Outsourced Applications
A	Jan	161.73	0
A	Feb	160.46	0
A	Mar	138.07	0
A	Apr	71.78	0
A	May	63.85	0
A	Jun	77.31	0
A	Jul	136.10	0
A	Aug	110.83	0
A	Sep	116.02	0
A	Oct	120.86	0
A	Nov	157.50	0
A	Dec	133.35	0
B	Jan	152.07	0
B	Feb	86.45	0
B	Mar	33.13	0
B	Apr	73.06	0
B	May	128.85	0
B	Jun	107.77	0
B	Jul	157.02	0
B	Aug	86.18	0
B	Sep	133.41	0
B	Oct	142.23	0
B	Nov	115.33	0
B	Dec	162.58	0
C	Jan	35.86	0
C	Feb	64.70	0
C	Mar	63.27	0
C	Apr	70.66	0
C	May	65.06	0
C	Jun	56.23	0
C	Jul	31.51	0
C	Aug	82.11	0
C	Sep	28.46	0
C	Oct	82.31	0
C	Nov	35.40	0
C	Dec	76.85	0

- The company has to spend \$18.14 m when there is a 10% limit on outsourcing and outsourcing costs increase by 20%
- Additional cost per application is \$1.6 compared to the actual scenario
- **The company will not outsource at all in this scenario**

Worst Case Scenario

State	Month	Full-Time Equivalents	Outsourced Applications
A	Jan	187.14	0
A	Feb	131.35	1463
A	Mar	212.21	0
A	Apr	76.57	0
A	May	71.14	0
A	Jun	61.27	682
A	Jul	155.58	1600
A	Aug	90.77	1011
A	Sep	134.25	0
A	Oct	95.04	1058
A	Nov	124.96	1285
A	Dec	151.21	1554
B	Jan	105.61	1970
B	Feb	60.65	1051
B	Mar	63.75	1189
B	Apr	46.77	335
B	May	86.14	1608
B	Jun	72.65	1258
B	Jul	106.73	1708
B	Aug	60.46	1048
B	Sep	96.82	1806
B	Oct	95.88	1662
B	Nov	78.46	1254
B	Dec	105.71	1690
C	Jan	41.50	0
C	Feb	0.00	1967
C	Mar	67.79	0
C	Apr	75.37	0
C	May	72.50	0
C	Jun	0.00	1642
C	Jul	0.00	2439
C	Aug	0.00	2436
C	Sep	32.93	0
C	Oct	0.00	2421
C	Nov	0.00	363
C	Dec	0.00	1398

- The company has to spend \$19.6 m in the worst case scenario
- Optimal number of staffs is 2,761
- Percentage of outsourced applications is around 35%
- Average cost per application is \$173, *the highest amongst all the scenarios*

Best Case Scenario

State	Month	Full-Time Equivalents	Outsourced Applications
A	Jan	145.56	0
A	Feb	143.47	0
A	Mar	185.63	0
A	Apr	67.56	0
A	May	58.53	0
A	Jun	71.03	0
A	Jul	177.80	0
A	Aug	39.15	0
A	Sep	104.42	0
A	Oct	110.28	0
A	Nov	142.80	0
A	Dec	185.11	0
B	Jan	136.86	0
B	Feb	77.23	0
B	Mar	92.34	0
B	Apr	68.76	0
B	May	118.24	0
B	Jun	38.34	0
B	Jul	85.43	1708
B	Aug	77.06	0
B	Sep	125.47	0
B	Oct	129.84	0
B	Nov	62.77	1254
B	Dec	30.61	1630
C	Jan	32.28	0
C	Feb	57.85	0
C	Mar	53.31	0
C	Apr	66.50	0
C	May	53.71	0
C	Jun	51.31	0
C	Jul	82.37	0
C	Aug	73.41	0
C	Sep	25.61	0
C	Oct	75.66	0
C	Nov	32.10	0
C	Dec	71.36	0

- The company has to spend \$16.5 m in the best case scenario
- Optimal number of staffs is 3,343
- Percentage of outsourced applications is only around 4.1%
- Average cost per application is \$146, *the lowest amongst all the scenarios*

Vendor Constraint

State	Month	Full-Time Equivalents	Outsourced_ Applications _Vendor1	Outsourced_ Applications _Vendor2
A	Jan	161.73	0	0
A	Feb	160.46	0	0
A	Mar	198.07	0	0
A	Apr	71.78	0	0
A	May	63.85	0	0
A	Jun	70.21	135	90
A	Jul	176.62	318	212
A	Aug	110.89	0	0
A	Sep	116.02	0	0
A	Oct	108.87	210	140
A	Nov	141.88	255	170
A	Dec	179.54	309	206
B	Jan	152.07	0	0
B	Feb	77.89	156	104
B	Mar	83.30	177	118
B	Apr	73.06	0	0
B	May	128.85	0	0
B	Jun	97.16	186	124
B	Jul	141.40	255	170
B	Aug	77.63	156	104
B	Sep	139.41	0	0
B	Oct	128.08	249	166
B	Nov	103.93	186	124
B	Dec	146.42	252	168
C	Jan	35.86	0	0
C	Feb	64.70	0	0
C	Mar	63.27	0	0
C	Apr	70.66	0	0
C	May	65.06	0	0
C	Jun	56.23	0	0
C	Jul	82.50	147	98
C	Aug	82.11	0	0
C	Sep	28.46	0	0
C	Oct	82.91	0	0
C	Nov	31.91	57	38
C	Dec	69.35	117	78

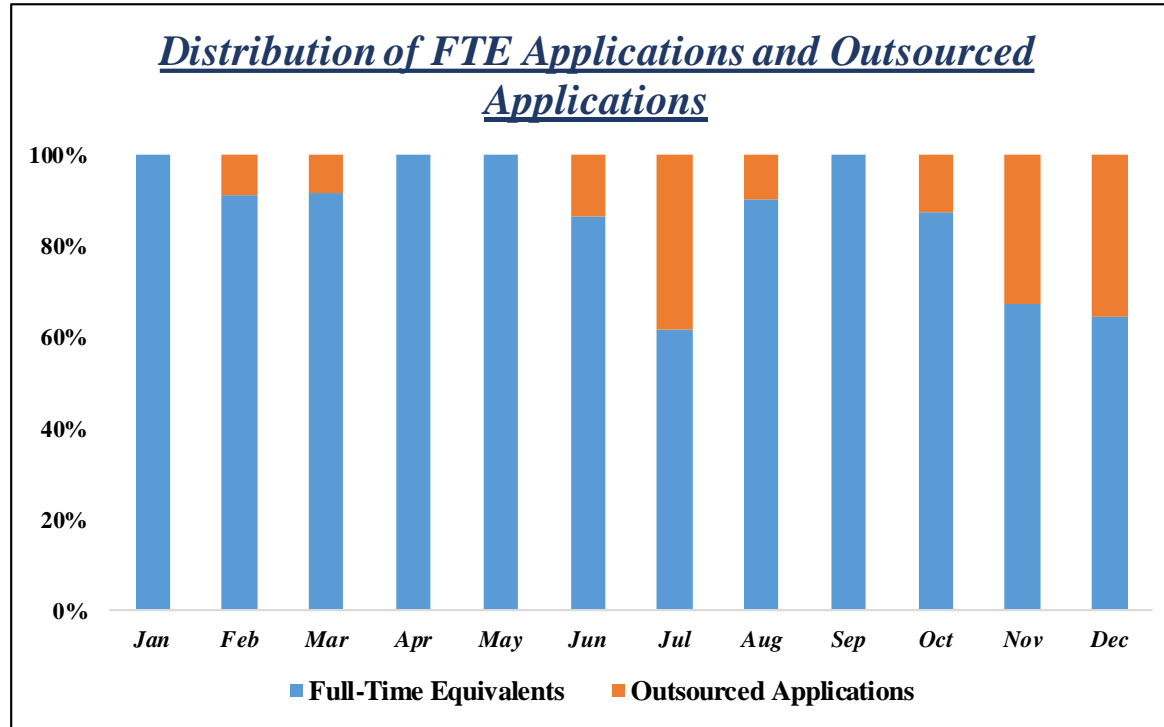
- The company has to spend \$18.1 m when there is a 60:40 ratio constraint on the vendors as well as the limit on outsourcing as 10%
- The optimal number of staffs required is 3,648

Relaxing the Ratio Constraint for Vendors

State	Month	Full-Time Equivalents	Outsourced_ Applications_ Vendor1	Outsourced_ Applications_ Vendor2
A	Jan	161.73	0	0
A	Feb	0.00	0	4878
A	Mar	0.00	0	5342
A	Apr	0.00	0	2237
A	May	0.00	0	1332
A	Jun	0.00	0	2275
A	Jul	0.00	0	5334
A	Aug	0.00	0	3371
A	Sep	116.02	0	0
A	Oct	0.00	0	3523
A	Nov	0.00	0	4284
A	Dec	0.00	0	5183
B	Jan	152.07	0	0
B	Feb	0.00	2628	0
B	Mar	0.00	2374	0
B	Apr	73.06	0	0
B	May	128.85	0	0
B	Jun	0.00	3147	0
B	Jul	0.00	4271	0
B	Aug	0.00	2620	0
B	Sep	133.41	0	0
B	Oct	0.00	4155	0
B	Nov	0.00	3137	0
B	Dec	0.00	4227	0
C	Jan	35.86	0	0
C	Feb	64.70	0	0
C	Mar	63.27	0	0
C	Apr	70.66	0	0
C	May	65.06	0	0
C	Jun	56.23	0	0
C	Jul	0.00	0	2483
C	Aug	82.11	0	0
C	Sep	28.46	0	0
C	Oct	82.31	0	0
C	Nov	0.00	0	363
C	Dec	0.00	0	1338

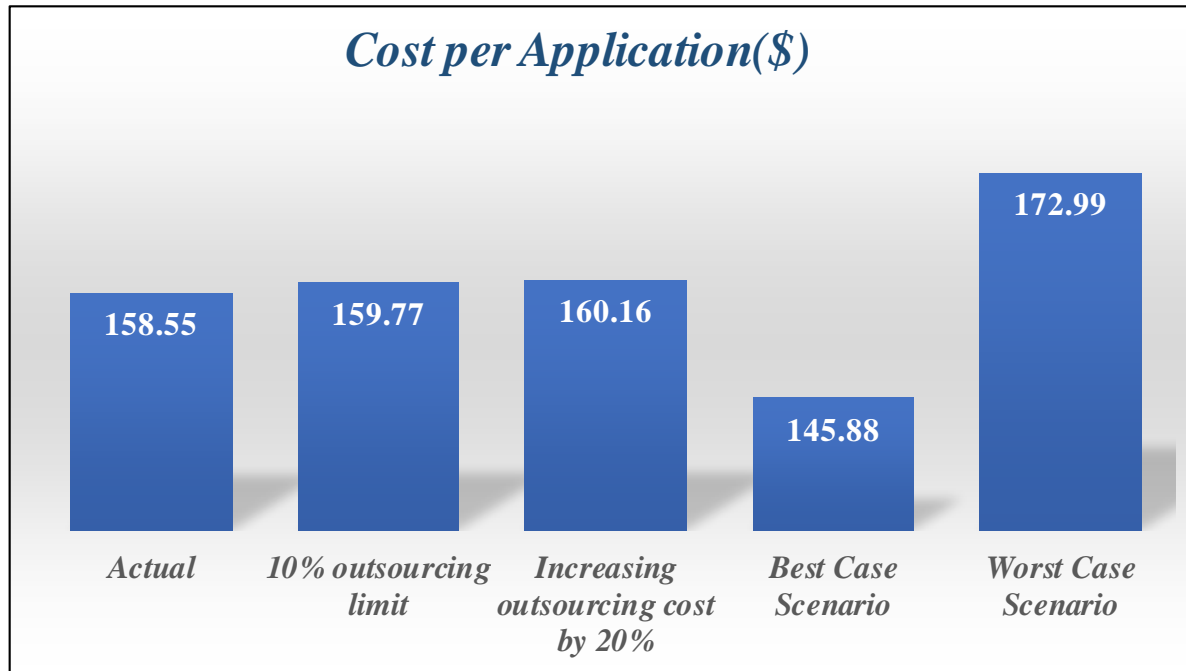
- The company has to spend around \$17.1 m on relaxing the ratio criterion
- Optimal allocation of applications outsourced is 27,159 for vendor 1 and 44,535 for vendor 2 and optimal staffs in 1320

Distribution of FTE Applications and Outsourced Applications in Actual Scenario



- As we can see, the outsourced applications are the highest in the months of July and November-December
- FTE's dominate fully in January, April, May and September

Cost per Application in the Different Scenarios



- The cost per application is the lowest in the best case scenario and the highest in the worst case scenario. It is quite natural as in the worst case scenario, the availability of FTE's is a concern and most of the applications have to be outsourced to meet the demands.