CONFERENCE LOCATION PLANNING

Group 01
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INTRODUCTION:

RSM US LLP is a leading audit, tax, and consulting service provider focused on empowering professionals and organizations with tailored solutions. The COVID-19 pandemic brought unprecedented change to companies of all sizes, including RSM. The savings on travel expenses during this time were significant, but the value of honest, personal interactions was missed.

After the pandemic, RSM aims to host a one-day event for associates, senior associates, and supervisors to renew working relationships and support future growth. This project is an attempt to optimize the Conference Location Selection by balancing cost efficiency and logistical feasibility through the use of Constrained Optimization methods.

OBJECTIVE:

The project aims to select an optimal location amongst the given options for a post-pandemic tax professionals' conference. The goal is to balance cost efficiency and logistical feasibility by minimizing overall costs, including travel, accommodation and lost client billable hours. Additionally, this project also looks at optimizing the number of rooms to be booked, taking into account the potential absence of some invitees to the conference.

DATA OVERVIEW:

The data consists of four disparate tables with information on Employees, Office Locations, Flights, and conference locations:

Employees Table: contains information on 3,579 employees. Employee attributes include Name, Level/Position, Office, Bill Rate, and Presenter status.

Office Locations Table: contains information on 75 unique office locations of RSM US LLP. Attributes for each office include Address, City, State, and Zip code.

Flights Table: contains details of over 768,000 different flights from various airlines. The attributes included for each flight are Airline code, Airline, Departing airport/city, Arriving airport/city, Departure/Arrival time, and Average Market Rate (Price).

Conference Locations Table: includes details on 28 different conference centers located in one of the six cities. The attributes included Address, City, State, ZIP code, Nearby Airport, Hotel Price, Discounted Hotel Price, Maximum Occupancy, and Meal Costs (Breakfast, Lunch, and Dinner per Person).

A sample of a few observations of each of these tables is given in the Appendix.

DATA PRE-PROCESSING:

The execution of this project involved significant data cleaning and preprocessing steps:

1. Standardized the city names across datasets (e.g., Raleigh/Durham to Durham, added missed punctuations like St. Louis)
2. Removed duplicate entries and rows with missing flight data
3. Fixed datatype of flight times and harmonized Time Zones: The arrival and

Departure times of the flights were given in the time zones of the respective cities. However, to calculate the duration of the flight accurately, time zones had to be harmonized across the arrival and departure cities.

4. Calculated Duration of Flights
5. Integrated the disparate datasets to get relevant information, such as departing airport codes for the employees. (Required Employees to be matched with Office table to get the ideal airport code for that office)
6. Data Filtering:
   a. Out of all the 3,579 employees, only associates, senior associates, supervisors, and presenters were invited to the conference, which amounted to 1,831 people.
   b. Out of 700,000+ flights, those not departing from any of the relevant office locations or those that are not arriving at the six chosen destination airports were filtered out. Further flights that traveled after midnight were also removed for practical purposes, bringing down the choice of flights to ~70,000.
   c. Finally, since there are 1,831 maximum attendees, any conference with a capacity lower than the above was dropped.
7. Calculated Notional costs for each person:
   (Bill rate*duration of flight) + flight ticket price
   One of the primary considerations in the problem was choosing a conference location that would minimize the loss of productive hours in travel. Therefore, we calculated the cost of travel as the sum of Costs due to lost time for each person (Bill rate * Duration) and Costs due to flight ticket prices.

APPROACH:

Despite bringing down the number of elements significantly by filtering the flights, Employees, and Conference locations for an optimization set-up, it was still a vast search space. Mainly, 70,000+ flights had to be narrowed down further to make the problem a little simpler.

We chose to break down the problem into two steps: First, we built a cost matrix for each person to travel to each of the six destination airports. Then, use this Cost matrix to set up a Facility Location Problem.

STEP 1:
Assuming that each person can take only the cheapest flight (cheapest including the opportunity cost of travel time) to any of the six destination airports, a cost matrix was developed for each person.

Name	Bill Rate(per hr)	Departing Airport	ATL	BNA	ORD	MCO	LAS	DFW
Aaron Clark	$ 330.00	PHX	1796.2	1456.2	1472.8	1945.2	144.6	1075.8
Abel Harvey	$ 405.00	JFK	900.5	559.6	586.0	1038.7	1021.8	1019.3
Ada Lawrence	$ 325.00	OKC	1004.5	1000000.0	762.5	1280.5	283.9	446.2
Ada McCormick	$ 270.00	CID	856.6	487.6	406.6	1179.5	455.2	602.7
Adam Gallegos	$ 330.00	CLT	357.8	181.1	375.0	585.0	613.0	584.4
Adam Ingram	$ 420.00	STL	1119.7	606.8	533.0	1370.0	623.8	827.2
Adam Padilla	$ 290.00	ORD	861.4	498.2	0.0	1083.6	502.1	642.0
Adam Stevens	$ 330.00	MSP	1156.9	722.8	497.4	1412.7	509.8	835.6
Adrienne Moody	$ 405.00	DAL	1195.4	727.6	916.5	1389.9	297.0	0.0
Al Cannon	$ 270.00	DAL	857.9	552.1	673.5	980.4	249.7	0.0
Al Fox	$ 270.00	BWI	559.9	186.9	335.5	662.0	567.9	691.1
Al George	$ 330.00	PHX	1796.2	1456.2	1472.8	1945.2	144.6	1075.8
Alan Cannon	$ 440.00	JFK	962.3	591.7	622.8	1116.2	1092.9	1092.8
Alan Hale	$ 330.00	CLT	357.8	181.1	375.0	585.0	613.0	584.4
Alan Walker	$ 330.00	DAL	1007.9	630.1	781.5	1162.4	270.7	0.0
Albert Hogan	$ 405.00	STL	1085.4	593.8	517.3	1326.7	606.3	805.0
Albert Lowe	$ 330.00	MSP	1156.9	722.8	497.4	1412.7	509.8	835.6
Alberto Patterson	$ 290.00	DAL	907.9	578.1	709.5	1041.1	256.7	0.0
Alberto Poole	$ 270.00	DAL	857.9	552.1	673.5	980.4	249.7	0.0

In the above figure, Employees named Adrianne Moody and Al Cannon have their departing airport as DAL (Dallas). Since there are no flights between Dallas and DFW, the null values in such situations were imputed with a value of 0.
We also observed that there are some pairs of airports with no direct flights. We chose to attribute the costs for such combinations with a large number ($10,000) as a flat penal rate for the additional time lost and the hassles associated.

STEP 2:
We then used the above-developed Cost Matrix to set up a Facility Location Problem using Constrained Optimization. One last process that was necessary before setting up the Optimizer was to calculate the fixed costs for each of the Conference Locations, assuming a 100% attendance ratio. The fixed costs were calculated as the sum of per person breakfast, lunch, and dinner costs added to room costs, multiplied by 1831 (No of attendees). This was calculated for each of the Conference locations.

FACILITY LOCATION PROBLEM:

After all the cleaning and processing, the facility location problem was set up as follows:

- O is the set of Employees = {1831 persons from 37 different office locations}
- D is the set of Conference Locations = {28 centers; 5 in ATL, 4 in BNA, 5 in DFW, 5 in LAS, 5 in MCO, 4 in ORD}

Parameters:

- oij: The cost of travel (flight ticket costs + billable hours lost) for the employee i ∈ O to conference location $j \in D$
- dj: The cost of hosting the event in the conference location $j \in D$

Decision Variables:

- xij = 1 if the flight is from office location i ∈ O to conference location j ∈ D, 0 otherwise
- yj = 1 if conference location $j \in D$ is chosen, 0 otherwise

Objective Function:

- Minimize: $\sum_{j\in D}\sum_{i\in O} oij \,.\, xij + \sum_{j\in D} dj \,.\, yj$

Constraints:

- Only 1 conference location must be selected $\sum_{j\in D} yj = 1 \quad \forall j \in D$
- A conference must be opened if any person is assigned to it $\sum_{i\in O} xij <= 1831 \,.\, yj \quad \forall j \in D$
- Binary Constraints
  $xij \in \{0,1\} \quad \forall i \in O, j \in D$
  $yj \in \{0,1\} \quad \forall i \in O, j \in D$

Solving the above Optimization problem provides the following solutions:

	Option 1	Option 2	Option 3
Optimal Location	ATL3	ATL4	ATL5
Hotel Name	**Americas Mart**	Believe Music Hall	Opera
Room Price	$ 145	$ 155	$ 175
Discounted Room Price	$ 116	$ 124	$ 140
Total Cost	**$ 664,177**	$ 694,417	$ 721,897

The best choice for the Conference Centre would, therefore, be **Americas Mart in Atlanta**.

OPTIMAL NUMBER OF ROOMS:

We went a step further to determine the optimal number of Rooms to book, considering that there could be some absentees

Key Assumption: We assume a uniform distribution of attendees between 85% and 100%: [1556,1831]

- **Underage cost,** $C_u = \$145$
  Cost of not booking enough rooms, requiring full-price payment for extra rooms
- **Overage cost,** $C_u = \$116$
  Cost of booking extra rooms, resulting in wasted payment for unused rooms

Critical Ratio: $\frac{C_u}{C_u+C_o} = \frac{116}{116+145} = 0.556$

EOQ = 1556 + 0.556 × (1831-1556) = 1708.79

The optimal number of rooms to book, therefore, is 1709

FINAL RECOMMENDATION:

- **Atlanta is the optimal location for the conference.** Even after removing the top option and re-running the analysis, Atlanta was the preferred choice. This validates its suitability based on multiple iterations of the model.
- **Cost efficiency: Atlanta** offers the lowest total cost, including billable hours lost, flight expenses, and hotel room costs.
- **Room allocation:** The optimal number of rooms to book is 1,709, balancing the risk of underbooking and overbooking rooms.

Simplification and Future Scope:

- **Flight Cost:** Assumes all attendees take the cheapest available flight. It does not account for personal preferences or alternative choices.
- **Travel Expenses:** Only considers the cost of one-way flights; Return flights are excluded
- **Future Scope:** Incorporating realistic assumptions such as shared accommodation, round-trip flight costs, and personal travel preference could provide more precise, actionable insights for decision-making.

Appendix

1. Colab link for the Python code:
   Operations_3.ipynb

2. Employees Table: The first few observations in the Employees' table

	A	B	C	D	E	F
1	Name	Level	Office	Bill Rate	Presenter	
2	Aaron Adams	Manager	New York, NY	665		
3	Aaron Clark	Senior Associate	Phoenix, AZ	330		
4	Aaron Jennings	Sr Manager	Houston, TX	755		
5	Aaron Richardson	Manager	San Francisco, CA	665		
6	Abby French	Manager	Charlotte, NC	605		
7	Abel Harvey	Senior Associate	New York, NY	405		
8	Abel Hunt	Manager	Seattle, WA	665		
9	Abel Patrick	Associate	San Antonio, TX	290		
10	Abraham Hicks	Sr Manager	Los Angeles, CA	755		

3. Office Locations Table: First few observations in the Office Locations Table

	A	B	C	D	E	F
1	Address Line1	Address Line2	Office City	Office State	ZIP	
2	1201 West Peachtree St. NW	Suite 800	Atlanta	GA	30309	
3	811 Barton Springs Road	Suite 500	Austin	TX	78704	
4	100 International Drive	Suite 1400	Baltimore	MD	21202	
5	216 Summit Blvd.	Suite 300	Birmingham	AL	35243	
6	518 Township Line Road	Suite 300	Blue Bell	PA	19422	
7	80 City Square		Boston	MA	02129	
8	201 First Street SE	Suite 800	Cedar Rapids	IA	52401	
9	2021 S. 1st Street	Suite 110	Champaign	IL	61820	
10	300 South Tryon St.	Suite 1500	Charlotte	NC	28202	

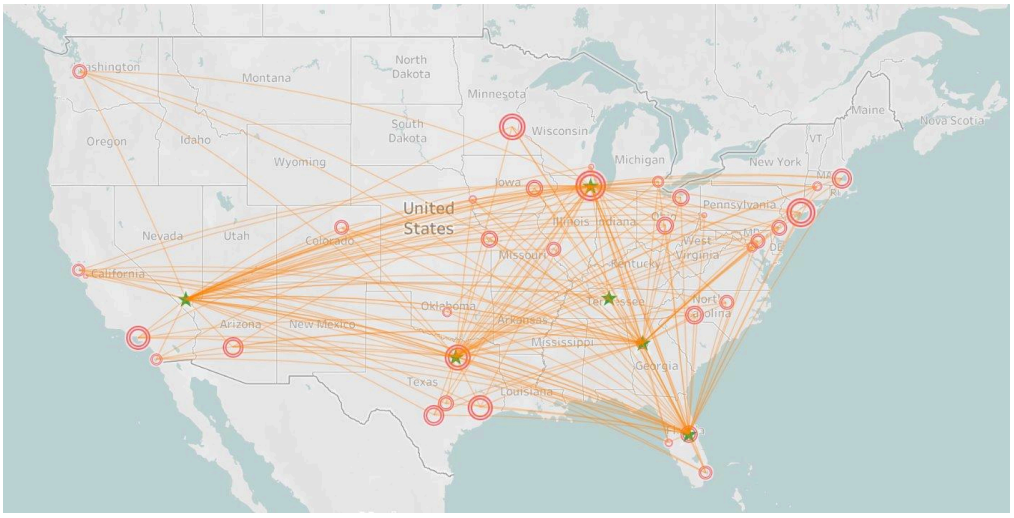
4. Flights Table: The first few observations in the Flights Table

	A	B	C	D	E	F	G	H	I	J
1	Airline Code	Airline	Departing Airport	Departing City	Destination Airport	Destination City	Departure Time	Arrival Time	Avg_MARKET_FARE	
2	AS	Alaska Airlines Inc.	ADQ	Kodiak, AK	ANC	Anchorage, AK	630	724	200.54	
3	AS	Alaska Airlines Inc.	ADQ	Kodiak, AK	ANC	Anchorage, AK	633	732	200.54	
4	AS	Alaska Airlines Inc.	ADQ	Kodiak, AK	ANC	Anchorage, AK	634	737	200.54	
5	AS	Alaska Airlines Inc.	ADQ	Kodiak, AK	ANC	Anchorage, AK	635	736	200.54	
6	AS	Alaska Airlines Inc.	ADQ	Kodiak, AK	ANC	Anchorage, AK	637	729	200.54	
7	AS	Alaska Airlines Inc.	ADQ	Kodiak, AK	ANC	Anchorage, AK	637	744	200.54	
8	AS	Alaska Airlines Inc.	ADQ	Kodiak, AK	ANC	Anchorage, AK	638	738	200.54	
9	AS	Alaska Airlines Inc.	ADQ	Kodiak, AK	ANC	Anchorage, AK	639	728	200.54	
10	AS	Alaska Airlines Inc.	ADQ	Kodiak, AK	ANC	Anchorage, AK	639	741	200.54	
11	AS	Alaska Airlines Inc.	ADQ	Kodiak, AK	ANC	Anchorage, AK	640	729	200.54	

5. Conference Locations Table: First few observations in Conference Locations Table

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Conference Center	Address	City	State	ZIP	Hotel Room Price	Discounted Hotel Ro	Maximum Occupancy	Catered Breakfast	Catered Lunch	Catered Dinner	Ideal Airport Code	
2	Las Vegas Convention Center	3150 Paradise Rd	Las Vegas	NV	89109	250	200	2300	12	22	35	LAS	
3	Sands Expo and Convention Center	201 Sands Ave	Las Vegas	NV	89169	300	240	1700	10	14	30	LAS	
4	Cashman Center	850 Las Vegas Blvd N	Las Vegas	NV	89101	160	128	2500	12	21	18	LAS	
5	Keep Memory Alive Event Center	888 W Bonnevilee Ave	Las Vegas	NV	89106	150	120	1850	8	14	25	LAS	
6	MGM Grand Conference Center	3799 Las Vegas Blvd S	Las Vegas	NV	89109	225	180	2000	9	16	28	LAS	
7	McCormick Place	2301 S Lake Shore Dr	Chicago	IL	60616	240	192	1950	11	15	29	ORD	
8	Navy Pier Festival Hall Complex	600 E Grand Ave	Chicago	IL	60611	220	176	2250	10	15	24	ORD	
9	South Shore Cultural Center	7059 S South Shore Dr	Chicago	IL	60649	180	144	1700	10	15	23	ORD	
10	Morgan MFG	401 N Morgan St	Chicago	IL	60642	280	224	1775	13	12	19	ORD	
11	Clarion Hotel Nashville Downtown	211 N 1st St	Nashville	TN	37213	135	108	1675	15	19	32	BNA	
12	The Westin Nashville	807 Clark Pl	Nashville	TN	37203	180	144	1800	20	18	31	BNA	
13	Hyatt Place Nashville Downtown	301 3rd Avenue South	Nashville	TN	37201	360	288	1650	6	21	33	BNA	
14	Hutton Hotel	1808 West End Ave	Nashville	TN	37203	120	96	1725	8	17	33	BNA	

6. Tableau Image: The problem we tried to solve



7. Tableau Image: The Solution