台湾啤酒®
TAIWAN BEER

Operations Research: Term project

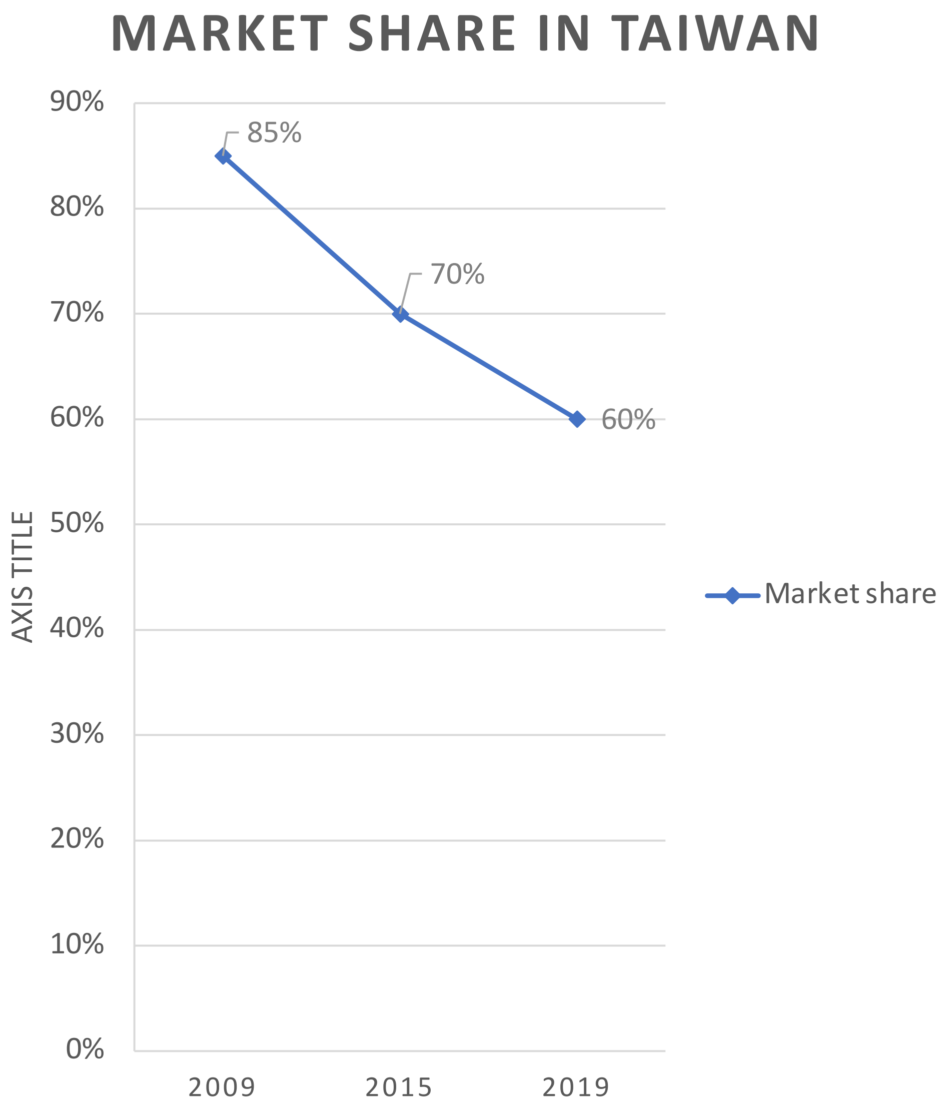
Taiwan Beer market research

Background - Business problem

- Taiwan Beer Is a well-established alcoholic beverage brand in Taiwan most famous for its green bottles and lager beers.
- Taiwan Beer has one big problem!
  - They have been losing market share to foreign brands and beer substitutes in the last decade.
- Market research shows that they are not as popular with the MZ generation and losing the younger drinkers.

Taiwan beer's market share in the Taiwanese beer market

- A falling market share of Taiwan beer in their own home market
- The trend away from lagers to more craft beers
- The forecast for 2023 is below 60% market share



Source: (Taiwan's Ministry of Finance)

Background – Xinyi

- Xinyi was chosen as a target district thanks to its vibrant and young nightlife by Taipei101
- It also boasts a cross-section of the average Taipei residents in the northern areas and the more rural and older population in the mountainous region.
- Taiwan Beer has decided to partner up with 7/11 to conduct market research in person at all of their locations in their Xinyi district.

Background - Solution and plan

Inspiration by the US, Taiwan Beer is planning to introduce a hard seltzer-like white claw into Taiwan, targeted to the MZ generation.

But to know if this is going to be a success they have decided to conduct interviews and market research in person.

Taiwan beer have made avalable up to 15 workers from the main office that can conduct the market resertch

Problem description

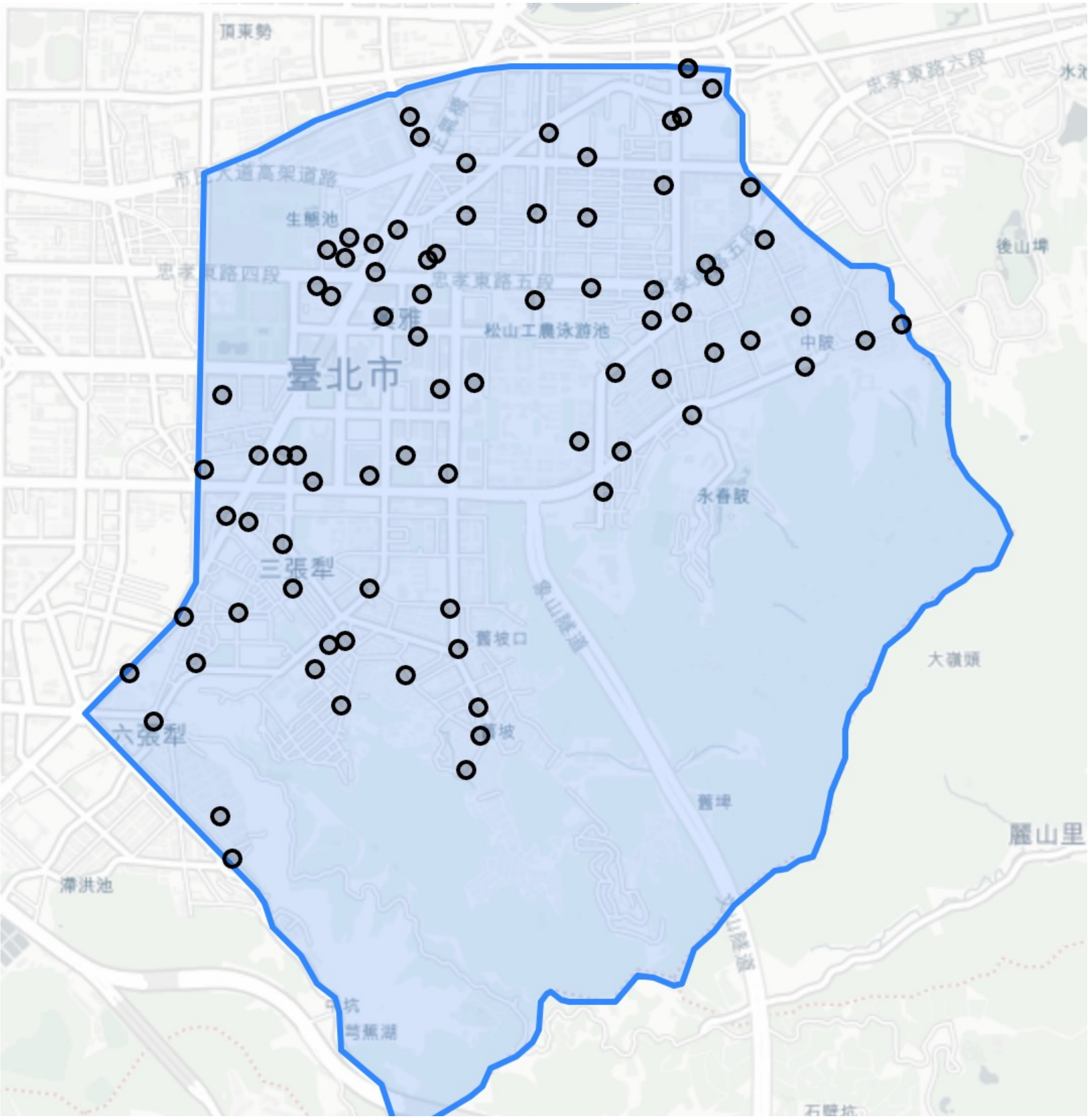
- Problem 1: Decide Which 7/11 to assign to which worker for market research
- Problem 2: Minimizing the distance the workers need to walk between their assigned 7/11s stores

- In total we have 81 stores in the Xinyi area, we have 15 available to use.

Problem 1

Facility location problem

Decide Which 7/11 to assign to which worker for market research



Picture 1: A map with all the 7/11 in the xinyi district plotted

All 7/11 locations in Xinyi District

Formulation

- To solve the first problem I choose to utilize the heuristic algorithm k-means-clustering. Bradley, et.al proposes a modified version that guarantees that we get no empty clusters.
- We modify the proposed algorithm with a non-linear integer program mindset. The decision variables are binary and indicate whether a cluster is used or not.

Sets and Parameters

Sets

- S: Set of 7/11 stores
- W: Set of workers

Parameters:

- d_i : Distance from store i to the centroid of its assigned cluster
- l: Minimum number of stores a worker must visit (4)
- u : Maximum number of stores a worker can visit (8)

Decision variables

- x^i is the store location of 7/11 store $i, \quad i = 1, \dots, 81$
- C^h is the centroid or the mean for cluster $h, \; h = 1, \dots, 15$
- $T_{i,h} = \begin{cases} 1 & \text{if store } i \text{ is assigned to worker } h \\ 0 & otherwise \end{cases}$

Objective function

$$\min_{C,T} \sum_{i=1}^{81} \sum_{h=1}^{15} T_{i,h} \left(\frac{1}{2} \left\| x^i - C^h \right\|_2^2 \right)$$

- Minimize the sum of squared distances from each store to the centroid of its assigned cluster

Constraint 1

$$\sum_{h=1}^{k} T_{i,h} = 1, \qquad i = 1 \ldots 81$$

- Each store must be assigned to exactly one worker

Constraint 2

$$l \leq \sum_{h=1}^{k} T_{i,h} \leq u \,, \forall i \in S$$

- Each worker must assigned to between l and u stores

Data

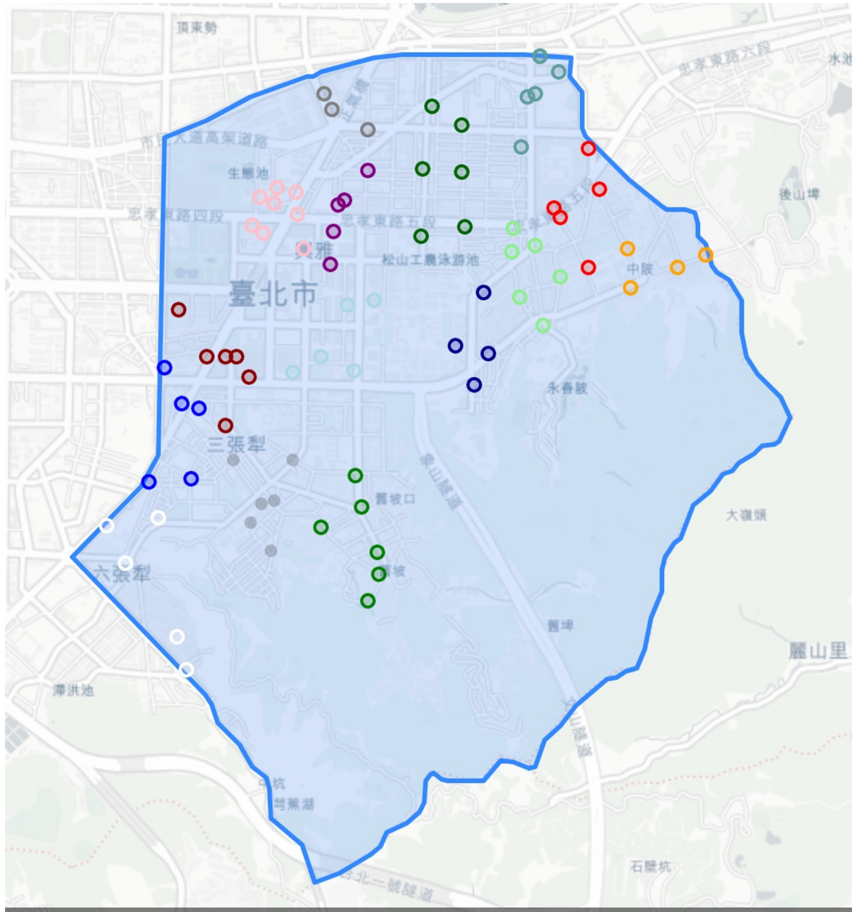
- The location data (addresses) was collected from Ibon’s website
  - There is some uncertainty if all 7/11 really do have an Ibon terminal but we assume.
- The address was then later converted to longitude and latitude using google maps
- Afterward, these longitude and latitude values were converted to an X-Y coordinate system using the Haversine distance
- Each of these steps is an estimation

Results – Clusters

Data output from our constrained k-means-clustering

```
[ 4  9  8  10  11  12  10  11  4  2  2  12  11  10  7  2
6  1  7  6  4  7  9  13  9  1  11  0  3  2  11  2  6  0  4
12  0  14  5  14  9  5  14  5  11  0  13  13  5  4  8  1
6  1  10  8  13  0  5  7  6  3  3  5  11  8  4  5  0  14  0
12  3  0  3  13  9  9  14  6  11]
```

- After running the k-mean-clustering heuristic until it reaches the stop constraint. We get an array of what cluster each of our stores is assigned to.
- We map each of the clusters to the corresponding 7/11 store and plot the results.



Picture 2: The Clusterings of 7/11s using the converts XY cordinates

Results

- We got 14 different clusters, thus which means we need 14 workers

Problem 2

Traveling salesmen problem

Minimizing the distance the workers need to walk between their assigned 7/11s stores

Background

- We have through the help of clustering or non-linear programming minimized the squared Euclidian distance between the 7/11 stores and the mean centroids.
- To help the employees we find the minimum distance route between the assigned 7/11 stores in their territory.
- We know that if we have 5 stores assigned to us for market research that is a total of 5!=120 ways to visit all the stores.

Sets, Parameters and variables

Sets

- S: Set of 7/11 stores
- W: Set of workers

Parameters

- d_{ij} : Euclidian distance between store *i* and store *j*
- l : Minimum number of stores a worker must visit (4)
- u: Maximum number of stores a worker can visit (8)

Variables

- x_{ijk}: $\begin{cases} 1 \text{ if worker } k \text{ travels from store } i \text{ to } j \\ 0 \quad \text{otherwise} \end{cases}$

Objective function

$$min \sum_{i \in S} \sum_{k \in W} \sum_{h \in S} d_{ij} x_{ijk}$$

- Minimize the total distance travelled by all workers

Constraint 1

$$\sum_{i \in S} \sum_{k \in W} x_{ijk} = 1 \,, \forall j \in S$$

- Each store must be visited exactly once by one worker

Constraint 2

$$l \leq \sum_{i \in S} \sum_{j \in S} x_{ijk} \leq u \, , \forall k \in W$$

- Each worker must visit between l and u stores

Constraint 3

$$\sum_{i \in S} x_{ijk} = \sum_{j \in S} x_{ijk}\,, \qquad \forall j \in S, \forall k \in W$$

- If a worker travels from store *i* to store j, they must leave store *j*

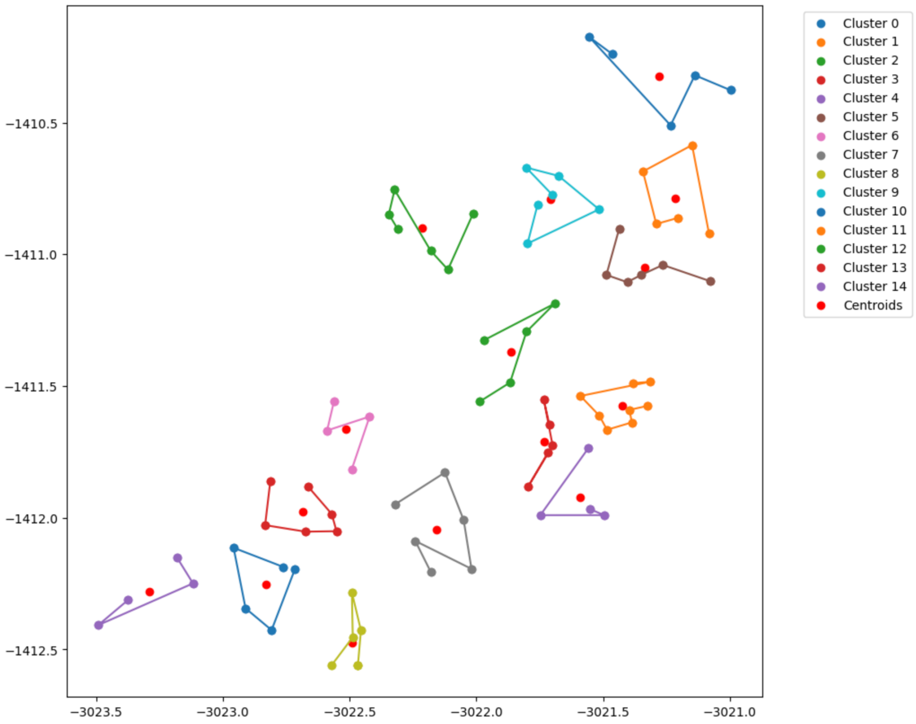
Result – TSP distance for each worker

- The distance that each worker takes with this path minimization

```
Total distance for cluster 0: 0.8725693559966072
Total distance for cluster 1: 0.9890694156360369
Total distance for cluster 2: 1.0678199177207133
Total distance for cluster 3: 0.7115391415677709
Total distance for cluster 4: 0.9236794692053527
Total distance for cluster 5: 1.0329727419582817
Total distance for cluster 6: 0.7694495357952365
Total distance for cluster 7: 1.2839513118902017
Total distance for cluster 8: 0.690986138020766
Total distance for cluster 9: 1.01314142364435
Total distance for cluster 10: 1.426285605901471
Total distance for cluster 11: 0.8427010774325971
Total distance for cluster 12: 1.040073196802327
Total distance for cluster 13: 0.8094911393588266
Total distance for cluster 14: 0.8584653382789587
```

Result – TSP for each worker

- Visually the sub-TSP looks reasonable, with no obvious outliers



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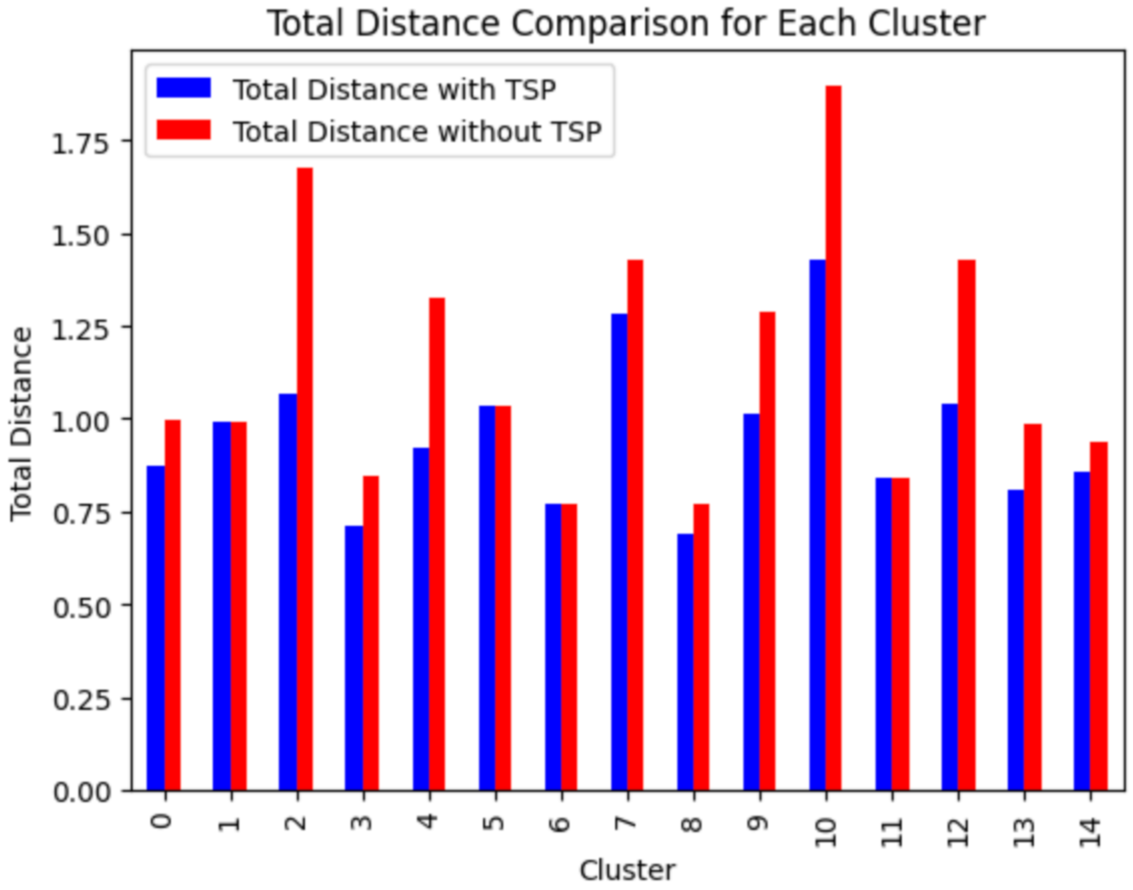

Conclusions

- We have shown that the TSP algorithm we used actually had the total distance or was the same.
- The clustering gave us defined areas and no empty clusters.
- Using these two methods we have helped Taiwan beer show that they only need 14 workers and that the route is optimal