

# Trying k-prototype to classify the respondents:

<https://antonsruberts.github.io/kproto-audience/>

- Reason for error in CO2 total during the power transformation: <https://github.com/scikit-learn/scikit-learn/issues/14959>
- Debugging: <https://github.com/lmcinnes/umap/issues/561>
- Reading for understanding K-prototype: <https://towardsdatascience.com/the-k-prototype-as-clustering-algorithm-for-mixed-data-type-categorical-and-numerical-fe7c50538ebb>
- Another reading for K-prototype: <https://zachary-a-zazueta.medium.com/k-prototypes-clustering-for-when-youre-clustering-continuous-and-categorical-data-6ea42c2ab2b9>
- For visualizing elbow plot and analyze the clustering results: <https://towardsdatascience.com/the-easiest-way-to-interpret-clustering-result-8137e488a127>
- Reading for SHAP value: <https://medium.com/@corymaklin/shap-shapley-additive-explanations-b8f0fce06202>
- SHAP value documentation: [https://shap.readthedocs.io/en/latest/example\\_notebooks/tabular\\_examples/tre](https://shap.readthedocs.io/en/latest/example_notebooks/tabular_examples/tre)
- UMAP readings:

<https://towardsdatascience.com/umap-dimensionality-reduction-an-incredibly-robust-machine-learning-algorithm-b5acb01de568>

<https://www.linkedin.com/pulse/one-minute-overview-umap-algorithm-saulius-dobilas/>

```
In [1]: import os
import json
import numpy as np
import pandas as pd
from pandas.io.json import json_normalize
from datetime import datetime
from tqdm import tqdm
from sklearn.preprocessing import PowerTransformer
from sklearn.preprocessing import StandardScaler
import umap.umap_ as umap

import matplotlib.pyplot as plt
import seaborn as sns
import plotly.graph_objects as go
from scipy import stats

from sklearn.cluster import KMeans
from kmodes.kprototypes import KPrototypes

from lightgbm import LGBMClassifier
```

```
import shap
from sklearn.model_selection import cross_val_score
```

C:\ProgramData\Anaconda3\lib\site-packages\scipy\\_\_init\_\_.py:146: UserWarning: A NumPy version >=1.16.5 and <1.23.0 is required for this version of SciPy (detected version 1.23.5)

```
warnings.warn(f"A NumPy version >={np_minversion} and <{np_maxversion}")
```

```
In [2]: # Loading the final cleaned dataset with extended variables

df = pd.read_csv('data_cleaned_descriptive_analysis_final.csv', header = 0)

pd.set_option('display.max_columns', None)
df.head(9)
```

```
Out[2]:
```

	Unnamed: 0	no_cars	gender	age	income	political_party	education	postal_code	EUROS
0	25	1.0	Weiblich	65	3000.0	CDU/CSU	(Fach-) Hochschulabschluss (Bachelor, Master, ...)	66440	
1	26	2.0	Weiblich	59	800.0	Keine Angabe	Allgemeine oder fachgebundene Hochschulreife/A...	65933	
2	27	0.0	Weiblich	60	1750.0	Keine Angabe	Berufsausbildung, Lehre oder Ausbildung an ein...	95028	
3	28	1.0	Männlich	73	2500.0	SPD	Realschulabschluss (Mittlere Reife) oder gleic...	63741	
4	30	0.0	Männlich	43	2500.0	Einer anderen Partei	Berufsausbildung, Lehre oder Ausbildung an ein...	13059	
5	31	1.0	Weiblich	49	2300.0	CDU/CSU	Berufsausbildung, Lehre oder Ausbildung an ein...	39112	
6	32	1.0	Weiblich	57	600.0	CDU/CSU	Realschulabschluss (Mittlere Reife) oder gleic...	78244	
7	33	2.0	Männlich	39	5000.0	SPD	(Fach-) Hochschulabschluss (Bachelor, Master, ...)	10115	
8	34	2.0	Männlich	62	0.0	Keine Angabe	(Fach-) Hochschulabschluss (Bachelor, Master, ...)	46149	

```
In [3]: df.columns
```

```
Out[3]: Index(['Unnamed: 0', 'no_cars', 'gender', 'age', 'income', 'political_party',
      'education', 'postal_code', 'EUROSTAT', 'RLK2022', 'KTU2022',
      'federal_state', 'NUTS2_NAME', 'NUTS3_NAME', 'CO2_housing',
      'CO2_electricity', 'CO2_housing_electricity', 'CO2_cruise',
      'CO2_flight', 'CO2_public_transport', 'CO2_car1', 'CO2_car2',
      'CO2_car3', 'CO2_car4', 'CO2_car5', 'CO2_car_total', 'CO2_mobility',
      'CO2_food', 'CO2_other_consumption', 'public_emission', 'CO2_total',
      'belief_housing_electricity', 'belief_mobility', 'belief_food',
      'belief_other_consumption', 'belief_total',
      'actual_rank_CO2_housing_electricity1', 'actual_rank_CO2_mobility1',
      'actual_rank_CO2_food1', 'actual_rank_CO2_other_consumption1',
      'actual_rank_CO2_total1', 'actual_rank_CO2_housing_electricity2',
      'actual_rank_CO2_mobility2', 'actual_rank_CO2_food2',
      'actual_rank_CO2_other_consumption2', 'actual_rank_CO2_total2',
      'belief_diff_housing_electricity', 'belief_diff_mobility',
      'belief_diff_food', 'belief_diff_other_consumption',
      'belief_diff_total'],
      dtype='object')
```

```
In [4]: df2 = df[['age', 'income', 'RLK2022', 'no_cars',
      'CO2_cruise', 'CO2_flight', 'CO2_public_transport', 'CO2_car_total', 'belief_
```

```
In [5]: ### Change column name: 'RLK2022' will be named as urban_rural_class as it is the vari

df2 = df2.rename(columns={'RLK2022': 'urban_rural_class'})
```

```
In [6]: df2.dtypes
```

```
Out[6]: age                int64
income              float64
urban_rural_class    object
no_cars             float64
CO2_cruise          float64
CO2_flight           float64
CO2_public_transport float64
CO2_car_total        float64
belief_diff_mobility float64
dtype: object
```

## Dimension Reduction using UMAP

```
In [7]: # Setting the graph style
sns.set(font_scale = 2)
sns.set_style("ticks")
```

```
In [8]: #Preprocessing numerical

np.random.seed(123)

numerical = df2.select_dtypes(exclude='object')

for c in numerical.columns:
    scaler = StandardScaler(with_std=False)
    pt = PowerTransformer(method='yeo-johnson', standardize=True)
    temp_array = scaler.fit_transform(np.array(numerical[c]).reshape(-1, 1))
    numerical.loc[:, c] = pt.fit_transform(temp_array)
```

```
##preprocessing categorical
categorical = df2.select_dtypes(include='object')
categorical = pd.get_dummies(categorical)

#Percentage of columns which are categorical is used as weight parameter in embeddings
categorical_weight = len(df2.select_dtypes(include='object').columns) / df2.shape[1]

#Embedding numerical & categorical
fit1 = umap.UMAP(metric='l2').fit(numerical) # euclidean
fit2 = umap.UMAP(metric='dice').fit(categorical)
```

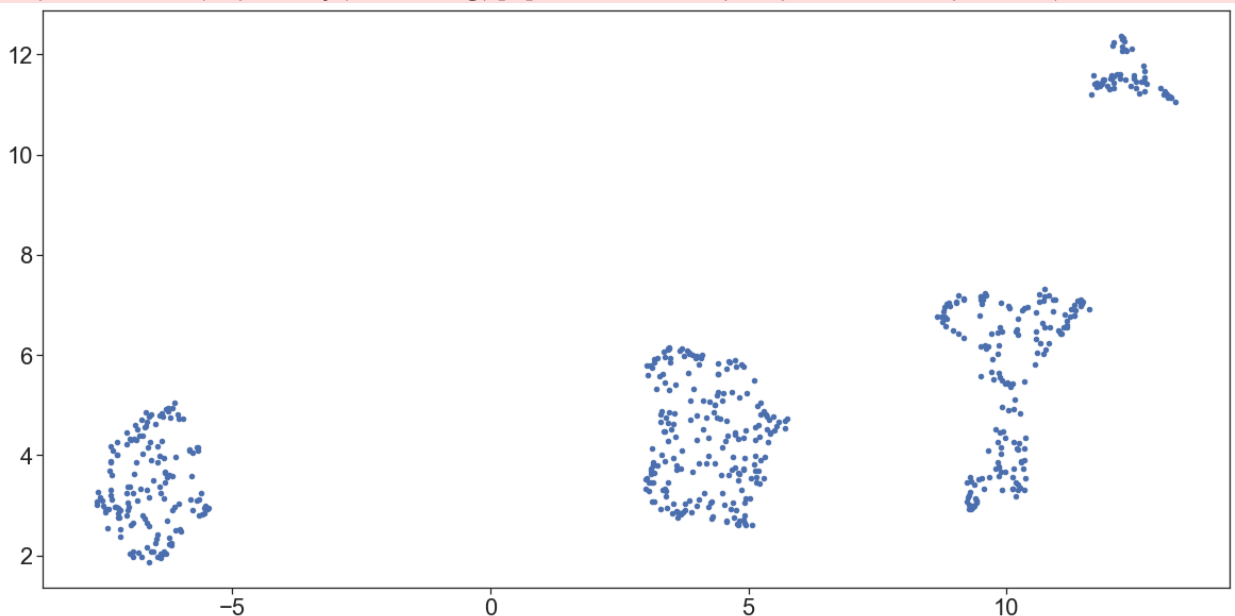
C:\Users\leajo\AppData\Roaming\Python\Python39\site-packages\umap\umap\_.py:1879: UserWarning: gradient function is not yet implemented for dice distance metric; inverse\_transform will be unavailable  
warn(

In [9]:

```
#Augmenting the numerical embedding with categorical
intersection = umap.general_simplicial_set_intersection(fit1.graph_, fit2.graph_, weight=categorical_weight)
intersection = umap.reset_local_connectivity(intersection)
embedding = umap.simplicial_set_embedding(fit1._raw_data, intersection, fit1.n_components, fit1._initial_alpha, fit1._a, fit1._b, fit1.repulsion_strength, fit1.negative_repulsion_strength, 200, 'random', np.random, fit1.metric, fit1._metric_kwds, False, {}, False)

plt.figure(figsize=(20, 10))
plt.scatter(*np.array(embedding)[0].T, s=20, cmap='Spectral', alpha=1.0)
plt.show()
```

C:\Users\leajo\AppData\Local\Temp\ipykernel\_20380\2483902116.py:11: VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences (which is a list-or-tuple of lists-or-tuples-or ndarrays with different lengths or shapes) is deprecated. If you meant to do this, you must specify 'dtype=object' when creating the ndarray.  
plt.scatter(\*np.array(embedding)[0].T, s=20, cmap='Spectral', alpha=1.0)



## K-prototype Clustering

- **IMPORTANT** : Before running this part, initialize UMAP first so that the UMAP does not take K-Prototype clusters as input.
- "distance" calculated is simply the number of disagreements between each data point and cluster mode centroid.

```
In [10]: ## Preparing the data by power transformation

kprot_data = df2.copy()

for c in df2.select_dtypes(exclude='object').columns:
    scaler = StandardScaler(with_std=False)
    pt = PowerTransformer(method='yeo-johnson', standardize=True)
    temp_array = scaler.fit_transform(np.array(kprot_data[c]).reshape(-1, 1))
    kprot_data[c] = pt.fit_transform(temp_array)
```

```
In [11]: # Elbow plot with cost

costs = []
n_clusters = []
clusters_assigned = []

for i in tqdm(range(2, 30)):
    try:
        kproto = KPrototypes(n_clusters=i, init='Cao', verbose=2)
        clusters = kproto.fit_predict(kprot_data, categorical=[2])
        costs.append(kproto.cost_)
        n_clusters.append(i)
        clusters_assigned.append(clusters)
    except:
        print(f"Can't cluster with {i} clusters")

fig = go.Figure(data=go.Scatter(x=n_clusters, y=costs))
fig.show();
```

```
0%|
| 0/28 [00:00<?, ?it/s]
```

Initialization method and algorithm are deterministic. Setting n\_init to 1.

Init: initializing centroids  
Init: initializing clusters  
Starting iterations...

Run: 1, iteration: 1/100, moves: 126, ncost: 3829.635770367964  
Run: 1, iteration: 2/100, moves: 47, ncost: 3790.8851035164935  
Run: 1, iteration: 3/100, moves: 16, ncost: 3781.767936287355  
Run: 1, iteration: 4/100, moves: 4, ncost: 3781.361609354872  
Run: 1, iteration: 5/100, moves: 2, ncost: 3781.27290379503  
Run: 1, iteration: 6/100, moves: 0, ncost: 3781.27290379503  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...

Run: 2, iteration: 1/100, moves: 85, ncost: 3795.729464601106  
Run: 2, iteration: 2/100, moves: 26, ncost: 3782.496790667561  
Run: 2, iteration: 3/100, moves: 4, ncost: 3781.7910167373316  
Run: 2, iteration: 4/100, moves: 1, ncost: 3781.7030954049055  
Run: 2, iteration: 5/100, moves: 1, ncost: 3781.62909010902  
Run: 2, iteration: 6/100, moves: 0, ncost: 3781.62909010902  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...

Run: 3, iteration: 1/100, moves: 87, ncost: 3911.8210365130262  
Run: 3, iteration: 2/100, moves: 28, ncost: 3883.8454891514343  
Run: 3, iteration: 3/100, moves: 39, ncost: 3830.149669074795  
Run: 3, iteration: 4/100, moves: 39, ncost: 3793.917303979616  
Run: 3, iteration: 5/100, moves: 19, ncost: 3783.4442776683254  
Run: 3, iteration: 6/100, moves: 12, ncost: 3781.116982589707  
Run: 3, iteration: 7/100, moves: 2, ncost: 3780.973102304374  
Run: 3, iteration: 8/100, moves: 1, ncost: 3780.899741780097  
Run: 3, iteration: 9/100, moves: 0, ncost: 3780.899741780097  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...

Run: 4, iteration: 1/100, moves: 65, ncost: 4013.5956785745175  
Run: 4, iteration: 2/100, moves: 50, ncost: 3939.8353659929467  
Run: 4, iteration: 3/100, moves: 48, ncost: 3866.026184781626  
Run: 4, iteration: 4/100, moves: 55, ncost: 3798.2384874916547  
Run: 4, iteration: 5/100, moves: 23, ncost: 3783.848259627947  
Run: 4, iteration: 6/100, moves: 10, ncost: 3781.058227154134  
Run: 4, iteration: 7/100, moves: 2, ncost: 3780.8997417800956  
Run: 4, iteration: 8/100, moves: 0, ncost: 3780.8997417800956  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...

Run: 5, iteration: 1/100, moves: 156, ncost: 3999.275596087398  
Run: 5, iteration: 2/100, moves: 116, ncost: 3805.3594671065925  
Run: 5, iteration: 3/100, moves: 35, ncost: 3784.354409813604  
Run: 5, iteration: 4/100, moves: 10, ncost: 3781.1419027072334  
Run: 5, iteration: 5/100, moves: 2, ncost: 3780.9731023043755  
Run: 5, iteration: 6/100, moves: 1, ncost: 3780.8997417800947  
Run: 5, iteration: 7/100, moves: 0, ncost: 3780.8997417800947  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...

Run: 6, iteration: 1/100, moves: 163, ncost: 3853.7991761310927  
Run: 6, iteration: 2/100, moves: 58, ncost: 3786.4671560545644  
Run: 6, iteration: 3/100, moves: 15, ncost: 3781.688889919419  
Run: 6, iteration: 4/100, moves: 1, ncost: 3781.62909010902  
Run: 6, iteration: 5/100, moves: 0, ncost: 3781.62909010902

```
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 76, ncost: 4054.6598625311913
Run: 7, iteration: 2/100, moves: 26, ncost: 4039.6330947810447
Run: 7, iteration: 3/100, moves: 21, ncost: 4030.3219932801317
Run: 7, iteration: 4/100, moves: 33, ncost: 3992.149664999861
Run: 7, iteration: 5/100, moves: 61, ncost: 3901.9663714275507
Run: 7, iteration: 6/100, moves: 59, ncost: 3812.035741784206
Run: 7, iteration: 7/100, moves: 34, ncost: 3788.4411428273993
Run: 7, iteration: 8/100, moves: 14, ncost: 3781.4220550162563
Run: 7, iteration: 9/100, moves: 5, ncost: 3780.9606281540096
Run: 7, iteration: 10/100, moves: 1, ncost: 3780.899741780095
Run: 7, iteration: 11/100, moves: 0, ncost: 3780.899741780095
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 68, ncost: 3881.7269503629964
Run: 8, iteration: 2/100, moves: 41, ncost: 3821.5205967153843
Run: 8, iteration: 3/100, moves: 38, ncost: 3789.1905568865445
Run: 8, iteration: 4/100, moves: 18, ncost: 3782.6584697776734
Run: 8, iteration: 5/100, moves: 6, ncost: 3781.141902707233
Run: 8, iteration: 6/100, moves: 2, ncost: 3780.9731023043746
Run: 8, iteration: 7/100, moves: 1, ncost: 3780.8997417800965
Run: 8, iteration: 8/100, moves: 0, ncost: 3780.8997417800965
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 187, ncost: 3904.582270859622
Run: 9, iteration: 2/100, moves: 89, ncost: 3815.796036644216
Run: 9, iteration: 3/100, moves: 34, ncost: 3789.423647181904
Run: 9, iteration: 4/100, moves: 19, ncost: 3782.658469777674
Run: 9, iteration: 5/100, moves: 6, ncost: 3781.1419027072347
Run: 9, iteration: 6/100, moves: 2, ncost: 3780.973102304375
Run: 9, iteration: 7/100, moves: 1, ncost: 3780.8997417800965
Run: 9, iteration: 8/100, moves: 0, ncost: 3780.8997417800965
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 10, iteration: 1/100, moves: 120, ncost: 3860.194502935387
Run: 10, iteration: 2/100, moves: 63, ncost: 3795.912829696861
Run: 10, iteration: 3/100, moves: 24, ncost: 3783.6207173232183
Run: 10, iteration: 4/100, moves: 9, ncost: 3780.9611188376393
Run: 10, iteration: 5/100, moves: 1, ncost: 3780.899741780096
Run: 10, iteration: 6/100, moves: 0, ncost: 3780.899741780096
Best run was number 5
```

4%|■■■

| 1/28 [00:02<01:06, 2.48s/it]

Initialization method and algorithm are deterministic. Setting n\_init to 1.

Init: initializing centroids

Init: initializing clusters

Starting iterations...

Run: 1, iteration: 1/100, moves: 178, ncost: 3685.039290532183  
Run: 1, iteration: 2/100, moves: 117, ncost: 3443.9955444395164  
Run: 1, iteration: 3/100, moves: 45, ncost: 3391.503063779744  
Run: 1, iteration: 4/100, moves: 51, ncost: 3340.7716302085787  
Run: 1, iteration: 5/100, moves: 36, ncost: 3315.631978690997  
Run: 1, iteration: 6/100, moves: 28, ncost: 3291.4950628106017  
Run: 1, iteration: 7/100, moves: 26, ncost: 3277.08746336294  
Run: 1, iteration: 8/100, moves: 21, ncost: 3268.2094837134905  
Run: 1, iteration: 9/100, moves: 14, ncost: 3263.4010871579417  
Run: 1, iteration: 10/100, moves: 11, ncost: 3259.905700602984  
Run: 1, iteration: 11/100, moves: 6, ncost: 3258.3623926534524  
Run: 1, iteration: 12/100, moves: 1, ncost: 3258.1940072818516  
Run: 1, iteration: 13/100, moves: 3, ncost: 3257.989398276982  
Run: 1, iteration: 14/100, moves: 0, ncost: 3257.989398276982

Init: initializing centroids

Init: initializing clusters

Starting iterations...

Run: 2, iteration: 1/100, moves: 163, ncost: 3742.5658457742634  
Run: 2, iteration: 2/100, moves: 123, ncost: 3536.188540280511  
Run: 2, iteration: 3/100, moves: 82, ncost: 3393.3369297280888  
Run: 2, iteration: 4/100, moves: 58, ncost: 3322.4729152556965  
Run: 2, iteration: 5/100, moves: 45, ncost: 3287.1956383638158  
Run: 2, iteration: 6/100, moves: 24, ncost: 3275.175068358634  
Run: 2, iteration: 7/100, moves: 23, ncost: 3265.029043821082  
Run: 2, iteration: 8/100, moves: 14, ncost: 3260.4064861491056  
Run: 2, iteration: 9/100, moves: 5, ncost: 3258.9041172501798  
Run: 2, iteration: 10/100, moves: 6, ncost: 3257.307010986808  
Run: 2, iteration: 11/100, moves: 2, ncost: 3257.1924653708725  
Run: 2, iteration: 12/100, moves: 0, ncost: 3257.1924653708725

Init: initializing centroids

Init: initializing clusters

Starting iterations...

Run: 3, iteration: 1/100, moves: 218, ncost: 3350.038390422613  
Run: 3, iteration: 2/100, moves: 85, ncost: 3269.566923214763  
Run: 3, iteration: 3/100, moves: 29, ncost: 3260.185981236298  
Run: 3, iteration: 4/100, moves: 12, ncost: 3257.7167377715928  
Run: 3, iteration: 5/100, moves: 5, ncost: 3257.1924653708725  
Run: 3, iteration: 6/100, moves: 0, ncost: 3257.1924653708725

Init: initializing centroids

Init: initializing clusters

Starting iterations...

Run: 4, iteration: 1/100, moves: 161, ncost: 3279.9744612661875  
Run: 4, iteration: 2/100, moves: 54, ncost: 3249.614959854526  
Run: 4, iteration: 3/100, moves: 22, ncost: 3241.6013900216853  
Run: 4, iteration: 4/100, moves: 2, ncost: 3241.443365142288  
Run: 4, iteration: 5/100, moves: 0, ncost: 3241.443365142288

Init: initializing centroids

Init: initializing clusters

Starting iterations...

Run: 5, iteration: 1/100, moves: 179, ncost: 3343.5297750308664  
Run: 5, iteration: 2/100, moves: 64, ncost: 3284.8318272940105  
Run: 5, iteration: 3/100, moves: 30, ncost: 3264.422770640365  
Run: 5, iteration: 4/100, moves: 27, ncost: 3248.661803858935  
Run: 5, iteration: 5/100, moves: 18, ncost: 3242.4486768828538  
Run: 5, iteration: 6/100, moves: 6, ncost: 3241.325444142386  
Run: 5, iteration: 7/100, moves: 0, ncost: 3241.325444142386



```
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 154, ncost: 3353.969067744883
Run: 6, iteration: 2/100, moves: 50, ncost: 3304.8244017376105
Run: 6, iteration: 3/100, moves: 33, ncost: 3280.7776427487393
Run: 6, iteration: 4/100, moves: 22, ncost: 3271.0175096894563
Run: 6, iteration: 5/100, moves: 17, ncost: 3264.4158405433495
Run: 6, iteration: 6/100, moves: 12, ncost: 3260.921015342024
Run: 6, iteration: 7/100, moves: 7, ncost: 3258.6195147330845
Run: 6, iteration: 8/100, moves: 3, ncost: 3258.141764206185
Run: 6, iteration: 9/100, moves: 2, ncost: 3257.989398276982
Run: 6, iteration: 10/100, moves: 0, ncost: 3257.989398276982
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 207, ncost: 3359.4921962151334
Run: 7, iteration: 2/100, moves: 65, ncost: 3308.937680947459
Run: 7, iteration: 3/100, moves: 36, ncost: 3281.495854191048
Run: 7, iteration: 4/100, moves: 16, ncost: 3273.0221324817976
Run: 7, iteration: 5/100, moves: 19, ncost: 3264.9097073494954
Run: 7, iteration: 6/100, moves: 15, ncost: 3260.9170207139096
Run: 7, iteration: 7/100, moves: 6, ncost: 3258.633149917717
Run: 7, iteration: 8/100, moves: 3, ncost: 3258.19400728185
Run: 7, iteration: 9/100, moves: 3, ncost: 3257.989398276983
Run: 7, iteration: 10/100, moves: 0, ncost: 3257.989398276983
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 154, ncost: 3385.5845576967386
Run: 8, iteration: 2/100, moves: 94, ncost: 3207.618439805241
Run: 8, iteration: 3/100, moves: 17, ncost: 3201.0304148931386
Run: 8, iteration: 4/100, moves: 2, ncost: 3200.938037689162
Run: 8, iteration: 5/100, moves: 0, ncost: 3200.938037689162
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 143, ncost: 3390.1923558027624
Run: 9, iteration: 2/100, moves: 35, ncost: 3370.79008652118
Run: 9, iteration: 3/100, moves: 28, ncost: 3341.885057238411
Run: 9, iteration: 4/100, moves: 31, ncost: 3317.5435730415743
Run: 9, iteration: 5/100, moves: 32, ncost: 3291.902680759881
Run: 9, iteration: 6/100, moves: 27, ncost: 3277.0874633629405
Run: 9, iteration: 7/100, moves: 21, ncost: 3268.2094837134914
Run: 9, iteration: 8/100, moves: 14, ncost: 3263.4010871579417
Run: 9, iteration: 9/100, moves: 11, ncost: 3259.905700602983
Run: 9, iteration: 10/100, moves: 6, ncost: 3258.3623926534515
Run: 9, iteration: 11/100, moves: 1, ncost: 3258.1940072818506
Run: 9, iteration: 12/100, moves: 3, ncost: 3257.9893982769827
Run: 9, iteration: 13/100, moves: 0, ncost: 3257.9893982769827
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 10, iteration: 1/100, moves: 189, ncost: 3279.965532879622
Run: 10, iteration: 2/100, moves: 57, ncost: 3248.0956934161572
Run: 10, iteration: 3/100, moves: 19, ncost: 3242.3246404749243
Run: 10, iteration: 4/100, moves: 6, ncost: 3241.4607780574647
Run: 10, iteration: 5/100, moves: 2, ncost: 3241.325444142386
```

7%|██████

| 2/28 [00:06&lt;01:25, 3.30s/it]

Run: 10, iteration: 6/100, moves: 0, ncost: 3241.325444142386  
Best run was number 8  
Initialization method and algorithm are deterministic. Setting n\_init to 1.  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 1, iteration: 1/100, moves: 202, ncost: 3029.294484434544  
Run: 1, iteration: 2/100, moves: 83, ncost: 2890.805199840289  
Run: 1, iteration: 3/100, moves: 47, ncost: 2762.845025892329  
Run: 1, iteration: 4/100, moves: 11, ncost: 2756.4864303834624  
Run: 1, iteration: 5/100, moves: 0, ncost: 2756.4864303834624  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 2, iteration: 1/100, moves: 188, ncost: 3229.2151058667278  
Run: 2, iteration: 2/100, moves: 92, ncost: 3105.9202486211116  
Run: 2, iteration: 3/100, moves: 84, ncost: 3013.193831405395  
Run: 2, iteration: 4/100, moves: 58, ncost: 2967.2286772973252  
Run: 2, iteration: 5/100, moves: 38, ncost: 2948.346488585295  
Run: 2, iteration: 6/100, moves: 15, ncost: 2944.468189832537  
Run: 2, iteration: 7/100, moves: 4, ncost: 2943.7061092812796  
Run: 2, iteration: 8/100, moves: 1, ncost: 2943.644860411031  
Run: 2, iteration: 9/100, moves: 0, ncost: 2943.644860411031  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 3, iteration: 1/100, moves: 141, ncost: 3089.045722318904  
Run: 3, iteration: 2/100, moves: 58, ncost: 3003.8266367946594  
Run: 3, iteration: 3/100, moves: 49, ncost: 2919.3983708281535  
Run: 3, iteration: 4/100, moves: 28, ncost: 2878.8903805404675  
Run: 3, iteration: 5/100, moves: 40, ncost: 2757.6055337613416  
Run: 3, iteration: 6/100, moves: 3, ncost: 2756.6297125676097  
Run: 3, iteration: 7/100, moves: 2, ncost: 2756.5302446268943  
Run: 3, iteration: 8/100, moves: 0, ncost: 2756.5302446268943  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 4, iteration: 1/100, moves: 157, ncost: 3122.5408336994465  
Run: 4, iteration: 2/100, moves: 75, ncost: 3006.3954003825133  
Run: 4, iteration: 3/100, moves: 66, ncost: 2921.738595276875  
Run: 4, iteration: 4/100, moves: 52, ncost: 2785.8315392898653  
Run: 4, iteration: 5/100, moves: 18, ncost: 2758.1814571597374  
Run: 4, iteration: 6/100, moves: 7, ncost: 2756.6002814985636  
Run: 4, iteration: 7/100, moves: 1, ncost: 2756.490934315647  
Run: 4, iteration: 8/100, moves: 0, ncost: 2756.490934315647  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 5, iteration: 1/100, moves: 239, ncost: 3083.7746273296216  
Run: 5, iteration: 2/100, moves: 52, ncost: 3026.7064438702264  
Run: 5, iteration: 3/100, moves: 9, ncost: 3024.1401004958734  
Run: 5, iteration: 4/100, moves: 14, ncost: 3019.213979413574  
Run: 5, iteration: 5/100, moves: 19, ncost: 3011.4926533855714  
Run: 5, iteration: 6/100, moves: 30, ncost: 2980.9614910164228  
Run: 5, iteration: 7/100, moves: 26, ncost: 2960.2767670970316  
Run: 5, iteration: 8/100, moves: 40, ncost: 2936.7747677989437  
Run: 5, iteration: 9/100, moves: 18, ncost: 2932.461010992252  
Run: 5, iteration: 10/100, moves: 11, ncost: 2929.693969525959  
Run: 5, iteration: 11/100, moves: 31, ncost: 2905.7980479908056  
Run: 5, iteration: 12/100, moves: 47, ncost: 2870.8372746093182

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Run: 5, iteration: 13/100, moves: 28, ncost: 2851.368912307403
Run: 5, iteration: 14/100, moves: 24, ncost: 2841.0143390804847
Run: 5, iteration: 15/100, moves: 20, ncost: 2827.6038886931346
Run: 5, iteration: 16/100, moves: 13, ncost: 2823.2456335337392
Run: 5, iteration: 17/100, moves: 10, ncost: 2821.8336591353273
Run: 5, iteration: 18/100, moves: 2, ncost: 2821.710582400171
Run: 5, iteration: 19/100, moves: 0, ncost: 2821.710582400171
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 193, ncost: 2861.405209641303
Run: 6, iteration: 2/100, moves: 57, ncost: 2812.2900383464485
Run: 6, iteration: 3/100, moves: 35, ncost: 2786.3356409207618
Run: 6, iteration: 4/100, moves: 10, ncost: 2782.242825329769
Run: 6, iteration: 5/100, moves: 13, ncost: 2776.5068397883874
Run: 6, iteration: 6/100, moves: 5, ncost: 2775.4753762239898
Run: 6, iteration: 7/100, moves: 4, ncost: 2774.847665094922
Run: 6, iteration: 8/100, moves: 4, ncost: 2774.1650898687226
Run: 6, iteration: 9/100, moves: 1, ncost: 2774.123739314621
Run: 6, iteration: 10/100, moves: 0, ncost: 2774.123739314621
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 197, ncost: 3087.0129681580106
Run: 7, iteration: 2/100, moves: 83, ncost: 2915.927397259564
Run: 7, iteration: 3/100, moves: 48, ncost: 2777.740176119741
Run: 7, iteration: 4/100, moves: 10, ncost: 2775.7959104052593
Run: 7, iteration: 5/100, moves: 5, ncost: 2775.0210153253083
Run: 7, iteration: 6/100, moves: 3, ncost: 2774.7617205415854
Run: 7, iteration: 7/100, moves: 0, ncost: 2774.7617205415854
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 167, ncost: 3187.0108434822305
Run: 8, iteration: 2/100, moves: 83, ncost: 3065.1222172269577
Run: 8, iteration: 3/100, moves: 55, ncost: 3007.9577728106074
Run: 8, iteration: 4/100, moves: 39, ncost: 2981.4556487252994
Run: 8, iteration: 5/100, moves: 21, ncost: 2972.576520443256
Run: 8, iteration: 6/100, moves: 23, ncost: 2954.0482315153913
Run: 8, iteration: 7/100, moves: 22, ncost: 2944.887091810203
Run: 8, iteration: 8/100, moves: 6, ncost: 2944.075438482251
Run: 8, iteration: 9/100, moves: 0, ncost: 2944.075438482251
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 191, ncost: 3092.6144978233165
Run: 9, iteration: 2/100, moves: 56, ncost: 3061.704613068877
Run: 9, iteration: 3/100, moves: 37, ncost: 3040.099130914619
Run: 9, iteration: 4/100, moves: 24, ncost: 3031.486189934899
Run: 9, iteration: 5/100, moves: 14, ncost: 3026.8111261532645
Run: 9, iteration: 6/100, moves: 8, ncost: 3025.3036532526407
Run: 9, iteration: 7/100, moves: 4, ncost: 3024.6653912193665
Run: 9, iteration: 8/100, moves: 3, ncost: 3024.1431974717707
Run: 9, iteration: 9/100, moves: 2, ncost: 3023.9855769934875
Run: 9, iteration: 10/100, moves: 0, ncost: 3023.9855769934875
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 10, iteration: 1/100, moves: 224, ncost: 3028.232455172067
Run: 10, iteration: 2/100, moves: 91, ncost: 2877.6664789227525
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Run: 10, iteration: 3/100, moves: 43, ncost: 2835.0840304364606
Run: 10, iteration: 4/100, moves: 19, ncost: 2826.2828448288315
Run: 10, iteration: 5/100, moves: 9, ncost: 2823.228035363733
Run: 10, iteration: 6/100, moves: 8, ncost: 2821.937932128731
Run: 10, iteration: 7/100, moves: 2, ncost: 2821.7986245164448
Run: 10, iteration: 8/100, moves: 1, ncost: 2821.7105824001696
```

11%|██████████

| 3/28 [00:09<01:18, 3.14s/it]

Run: 10, iteration: 9/100, moves: 0, ncost: 2821.7105824001696  
Best run was number 1  
Initialization method and algorithm are deterministic. Setting n\_init to 1.  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 1, iteration: 1/100, moves: 198, ncost: 2710.1415726471796  
Run: 1, iteration: 2/100, moves: 75, ncost: 2578.3501021501784  
Run: 1, iteration: 3/100, moves: 25, ncost: 2565.0610345559376  
Run: 1, iteration: 4/100, moves: 9, ncost: 2562.457813876474  
Run: 1, iteration: 5/100, moves: 1, ncost: 2562.2272148196744  
Run: 1, iteration: 6/100, moves: 1, ncost: 2562.095793269721  
Run: 1, iteration: 7/100, moves: 1, ncost: 2561.8574658097177  
Run: 1, iteration: 8/100, moves: 0, ncost: 2561.8574658097177  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 2, iteration: 1/100, moves: 227, ncost: 2904.5935200503045  
Run: 2, iteration: 2/100, moves: 73, ncost: 2847.4686736035765  
Run: 2, iteration: 3/100, moves: 51, ncost: 2815.4233078773027  
Run: 2, iteration: 4/100, moves: 49, ncost: 2771.400626600839  
Run: 2, iteration: 5/100, moves: 48, ncost: 2719.284714143252  
Run: 2, iteration: 6/100, moves: 48, ncost: 2651.8926663268026  
Run: 2, iteration: 7/100, moves: 53, ncost: 2516.6490536573074  
Run: 2, iteration: 8/100, moves: 16, ncost: 2492.2724772682955  
Run: 2, iteration: 9/100, moves: 6, ncost: 2491.101590548437  
Run: 2, iteration: 10/100, moves: 0, ncost: 2491.101590548437  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 3, iteration: 1/100, moves: 238, ncost: 2782.2724327557426  
Run: 3, iteration: 2/100, moves: 91, ncost: 2643.9409104703273  
Run: 3, iteration: 3/100, moves: 59, ncost: 2576.1377227174685  
Run: 3, iteration: 4/100, moves: 48, ncost: 2530.6862462361455  
Run: 3, iteration: 5/100, moves: 23, ncost: 2519.080991835959  
Run: 3, iteration: 6/100, moves: 8, ncost: 2517.3516275376087  
Run: 3, iteration: 7/100, moves: 10, ncost: 2515.044518352767  
Run: 3, iteration: 8/100, moves: 8, ncost: 2510.4180053388022  
Run: 3, iteration: 9/100, moves: 16, ncost: 2496.806171049234  
Run: 3, iteration: 10/100, moves: 13, ncost: 2491.6428628752637  
Run: 3, iteration: 11/100, moves: 5, ncost: 2491.0334490432165  
Run: 3, iteration: 12/100, moves: 0, ncost: 2491.0334490432165  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 4, iteration: 1/100, moves: 147, ncost: 2796.185532777416  
Run: 4, iteration: 2/100, moves: 83, ncost: 2658.859300812919  
Run: 4, iteration: 3/100, moves: 54, ncost: 2548.8477023406554  
Run: 4, iteration: 4/100, moves: 35, ncost: 2514.735855911538  
Run: 4, iteration: 5/100, moves: 29, ncost: 2494.715114414955  
Run: 4, iteration: 6/100, moves: 13, ncost: 2491.16858426475  
Run: 4, iteration: 7/100, moves: 4, ncost: 2490.661222024677  
Run: 4, iteration: 8/100, moves: 0, ncost: 2490.661222024677  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 5, iteration: 1/100, moves: 212, ncost: 2872.5632492349378  
Run: 5, iteration: 2/100, moves: 111, ncost: 2729.523922514546  
Run: 5, iteration: 3/100, moves: 51, ncost: 2605.1710193913004  
Run: 5, iteration: 4/100, moves: 43, ncost: 2516.6225977939316

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Run: 5, iteration: 5/100, moves: 22, ncost: 2500.1047687590367
Run: 5, iteration: 6/100, moves: 16, ncost: 2491.8579724135393
Run: 5, iteration: 7/100, moves: 3, ncost: 2491.112846521141
Run: 5, iteration: 8/100, moves: 0, ncost: 2491.112846521141
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 135, ncost: 2896.0795247732603
Run: 6, iteration: 2/100, moves: 48, ncost: 2859.1417754520394
Run: 6, iteration: 3/100, moves: 69, ncost: 2714.9659891387455
Run: 6, iteration: 4/100, moves: 62, ncost: 2612.7256299783203
Run: 6, iteration: 5/100, moves: 38, ncost: 2581.993765894234
Run: 6, iteration: 6/100, moves: 15, ncost: 2576.0562275634225
Run: 6, iteration: 7/100, moves: 15, ncost: 2569.3219547416134
Run: 6, iteration: 8/100, moves: 15, ncost: 2561.688769569384
Run: 6, iteration: 9/100, moves: 3, ncost: 2561.1633487259537
Run: 6, iteration: 10/100, moves: 4, ncost: 2560.2597437322447
Run: 6, iteration: 11/100, moves: 4, ncost: 2559.410090758739
Run: 6, iteration: 12/100, moves: 6, ncost: 2557.7550779540225
Run: 6, iteration: 13/100, moves: 10, ncost: 2553.9148751254043
Run: 6, iteration: 14/100, moves: 6, ncost: 2552.700164746363
Run: 6, iteration: 15/100, moves: 1, ncost: 2552.6099632215914
Run: 6, iteration: 16/100, moves: 0, ncost: 2552.6099632215914
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 252, ncost: 2911.224204916241
Run: 7, iteration: 2/100, moves: 139, ncost: 2628.111094645146
Run: 7, iteration: 3/100, moves: 60, ncost: 2567.8111725799904
Run: 7, iteration: 4/100, moves: 43, ncost: 2522.803664329865
Run: 7, iteration: 5/100, moves: 27, ncost: 2508.136646714247
Run: 7, iteration: 6/100, moves: 23, ncost: 2492.9467623900023
Run: 7, iteration: 7/100, moves: 5, ncost: 2491.2179349957896
Run: 7, iteration: 8/100, moves: 1, ncost: 2491.112846521142
Run: 7, iteration: 9/100, moves: 0, ncost: 2491.112846521142
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 155, ncost: 2691.349315562324
Run: 8, iteration: 2/100, moves: 73, ncost: 2571.4553101076235
Run: 8, iteration: 3/100, moves: 52, ncost: 2522.8143013804292
Run: 8, iteration: 4/100, moves: 26, ncost: 2508.645213936075
Run: 8, iteration: 5/100, moves: 25, ncost: 2490.9129969580104
Run: 8, iteration: 6/100, moves: 2, ncost: 2490.713785395869
Run: 8, iteration: 7/100, moves: 0, ncost: 2490.713785395869
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 142, ncost: 2644.35218890605
Run: 9, iteration: 2/100, moves: 44, ncost: 2607.421455687216
Run: 9, iteration: 3/100, moves: 27, ncost: 2593.973423589568
Run: 9, iteration: 4/100, moves: 13, ncost: 2591.1203487970397
Run: 9, iteration: 5/100, moves: 16, ncost: 2586.1381756229894
Run: 9, iteration: 6/100, moves: 16, ncost: 2578.1567339901876
Run: 9, iteration: 7/100, moves: 33, ncost: 2551.4659555065336
Run: 9, iteration: 8/100, moves: 41, ncost: 2510.9965667619704
Run: 9, iteration: 9/100, moves: 16, ncost: 2503.6674608310527
Run: 9, iteration: 10/100, moves: 12, ncost: 2496.6676944348546
Run: 9, iteration: 11/100, moves: 7, ncost: 2494.7164495373163
Run: 9, iteration: 12/100, moves: 6, ncost: 2493.419459194155
```

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Run: 9, iteration: 13/100, moves: 4, ncost: 2492.9206408941714
Run: 9, iteration: 14/100, moves: 0, ncost: 2492.9206408941714
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 10, iteration: 1/100, moves: 210, ncost: 2712.050704422813
Run: 10, iteration: 2/100, moves: 85, ncost: 2620.94785864298
Run: 10, iteration: 3/100, moves: 44, ncost: 2581.761296944731
Run: 10, iteration: 4/100, moves: 15, ncost: 2575.6209796115713
Run: 10, iteration: 5/100, moves: 15, ncost: 2568.3186394032914
Run: 10, iteration: 6/100, moves: 17, ncost: 2559.9247781573226
Run: 10, iteration: 7/100, moves: 7, ncost: 2558.3280577208075
Run: 10, iteration: 8/100, moves: 7, ncost: 2556.177367188064
Run: 10, iteration: 9/100, moves: 8, ncost: 2553.345718074275
```

14%|██████████

| 4/28 [00:12<01:15, 3.14s/it]

```
Run: 10, iteration: 10/100, moves: 4, ncost: 2552.609963221593
Run: 10, iteration: 11/100, moves: 0, ncost: 2552.609963221593
Best run was number 4
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 1, iteration: 1/100, moves: 177, ncost: 2605.4186767536426
Run: 1, iteration: 2/100, moves: 70, ncost: 2529.471344176144
Run: 1, iteration: 3/100, moves: 41, ncost: 2481.4008342732404
Run: 1, iteration: 4/100, moves: 29, ncost: 2466.0900857636466
Run: 1, iteration: 5/100, moves: 11, ncost: 2463.793304381402
Run: 1, iteration: 6/100, moves: 3, ncost: 2463.0703502561623
Run: 1, iteration: 7/100, moves: 6, ncost: 2461.7114119381536
Run: 1, iteration: 8/100, moves: 1, ncost: 2461.6202784032866
Run: 1, iteration: 9/100, moves: 0, ncost: 2461.6202784032866
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 2, iteration: 1/100, moves: 188, ncost: 2591.090939628962
Run: 2, iteration: 2/100, moves: 77, ncost: 2504.816977846554
Run: 2, iteration: 3/100, moves: 60, ncost: 2446.5960079522006
Run: 2, iteration: 4/100, moves: 32, ncost: 2426.320455235913
Run: 2, iteration: 5/100, moves: 18, ncost: 2418.4252997894473
Run: 2, iteration: 6/100, moves: 5, ncost: 2416.9967833142773
Run: 2, iteration: 7/100, moves: 4, ncost: 2416.253399568326
Run: 2, iteration: 8/100, moves: 3, ncost: 2415.7327536684948
Run: 2, iteration: 9/100, moves: 3, ncost: 2415.268111590664
Run: 2, iteration: 10/100, moves: 3, ncost: 2414.7396362726936
Run: 2, iteration: 11/100, moves: 7, ncost: 2411.6027164066127
Run: 2, iteration: 12/100, moves: 12, ncost: 2404.046630422433
Run: 2, iteration: 13/100, moves: 17, ncost: 2392.3682307982617
Run: 2, iteration: 14/100, moves: 8, ncost: 2390.2461250768706
Run: 2, iteration: 15/100, moves: 4, ncost: 2389.797978569548
Run: 2, iteration: 16/100, moves: 0, ncost: 2389.797978569548
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 3, iteration: 1/100, moves: 164, ncost: 2659.604174127396
Run: 3, iteration: 2/100, moves: 84, ncost: 2550.2899708261875
Run: 3, iteration: 3/100, moves: 62, ncost: 2494.971742723711
Run: 3, iteration: 4/100, moves: 37, ncost: 2476.217554314276
Run: 3, iteration: 5/100, moves: 21, ncost: 2470.692955806262
Run: 3, iteration: 6/100, moves: 9, ncost: 2467.9198511353356
Run: 3, iteration: 7/100, moves: 8, ncost: 2466.520075480973
Run: 3, iteration: 8/100, moves: 6, ncost: 2464.636915224552
Run: 3, iteration: 9/100, moves: 7, ncost: 2462.0292176103885
Run: 3, iteration: 10/100, moves: 12, ncost: 2448.788835684013
Run: 3, iteration: 11/100, moves: 36, ncost: 2405.6470536516254
Run: 3, iteration: 12/100, moves: 21, ncost: 2392.81767561806
Run: 3, iteration: 13/100, moves: 27, ncost: 2372.779439999418
Run: 3, iteration: 14/100, moves: 23, ncost: 2352.9223921634643
Run: 3, iteration: 15/100, moves: 14, ncost: 2347.060588735085
Run: 3, iteration: 16/100, moves: 15, ncost: 2342.907878724906
Run: 3, iteration: 17/100, moves: 5, ncost: 2342.1154642893334
Run: 3, iteration: 18/100, moves: 4, ncost: 2341.651551415118
Run: 3, iteration: 19/100, moves: 4, ncost: 2341.0639115960034
Run: 3, iteration: 20/100, moves: 1, ncost: 2340.908487864867
Run: 3, iteration: 21/100, moves: 0, ncost: 2340.908487864867
Init: initializing centroids
```



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Init: initializing clusters
Starting iterations...
Run: 4, iteration: 1/100, moves: 194, ncost: 2428.572621196846
Run: 4, iteration: 2/100, moves: 64, ncost: 2378.2318036785387
Run: 4, iteration: 3/100, moves: 29, ncost: 2357.8519883426156
Run: 4, iteration: 4/100, moves: 11, ncost: 2355.693687693487
Run: 4, iteration: 5/100, moves: 3, ncost: 2355.0554204674913
Run: 4, iteration: 6/100, moves: 1, ncost: 2354.954309398643
Run: 4, iteration: 7/100, moves: 0, ncost: 2354.954309398643
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 5, iteration: 1/100, moves: 236, ncost: 2655.7748073744597
Run: 5, iteration: 2/100, moves: 98, ncost: 2554.315212860876
Run: 5, iteration: 3/100, moves: 57, ncost: 2484.4047021642923
Run: 5, iteration: 4/100, moves: 54, ncost: 2438.817261788732
Run: 5, iteration: 5/100, moves: 52, ncost: 2397.434533563438
Run: 5, iteration: 6/100, moves: 36, ncost: 2367.601080343638
Run: 5, iteration: 7/100, moves: 29, ncost: 2350.1321574660974
Run: 5, iteration: 8/100, moves: 14, ncost: 2343.0240429288147
Run: 5, iteration: 9/100, moves: 9, ncost: 2339.763602013703
Run: 5, iteration: 10/100, moves: 6, ncost: 2338.4328472738093
Run: 5, iteration: 11/100, moves: 5, ncost: 2336.3536855607854
Run: 5, iteration: 12/100, moves: 4, ncost: 2335.781350971767
Run: 5, iteration: 13/100, moves: 0, ncost: 2335.781350971767
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 172, ncost: 2446.3328811025713
Run: 6, iteration: 2/100, moves: 75, ncost: 2339.7565987891912
Run: 6, iteration: 3/100, moves: 18, ncost: 2334.1199309209746
Run: 6, iteration: 4/100, moves: 12, ncost: 2330.4425898238164
Run: 6, iteration: 5/100, moves: 6, ncost: 2329.173695553883
Run: 6, iteration: 6/100, moves: 5, ncost: 2328.2246187279943
Run: 6, iteration: 7/100, moves: 2, ncost: 2328.043514086795
Run: 6, iteration: 8/100, moves: 0, ncost: 2328.043514086795
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 163, ncost: 2611.8436435066737
Run: 7, iteration: 2/100, moves: 87, ncost: 2456.332986825067
Run: 7, iteration: 3/100, moves: 76, ncost: 2374.0460775166207
Run: 7, iteration: 4/100, moves: 40, ncost: 2350.523268841408
Run: 7, iteration: 5/100, moves: 17, ncost: 2343.285905329503
Run: 7, iteration: 6/100, moves: 13, ncost: 2337.002589662466
Run: 7, iteration: 7/100, moves: 8, ncost: 2334.845620566924
Run: 7, iteration: 8/100, moves: 5, ncost: 2333.909774722855
Run: 7, iteration: 9/100, moves: 5, ncost: 2333.224140334953
Run: 7, iteration: 10/100, moves: 0, ncost: 2333.224140334953
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 187, ncost: 2598.4856274029585
Run: 8, iteration: 2/100, moves: 79, ncost: 2498.0174002782383
Run: 8, iteration: 3/100, moves: 45, ncost: 2456.611491893046
Run: 8, iteration: 4/100, moves: 24, ncost: 2439.403423060069
Run: 8, iteration: 5/100, moves: 7, ncost: 2438.263098780623
Run: 8, iteration: 6/100, moves: 2, ncost: 2438.019637671671
Run: 8, iteration: 7/100, moves: 0, ncost: 2438.019637671671
Init: initializing centroids
```

```
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 263, ncost: 2850.207938289973
Run: 9, iteration: 2/100, moves: 148, ncost: 2551.649271462535
Run: 9, iteration: 3/100, moves: 76, ncost: 2470.6783433380524
Run: 9, iteration: 4/100, moves: 17, ncost: 2464.91744477051
Run: 9, iteration: 5/100, moves: 11, ncost: 2461.4585219878345
Run: 9, iteration: 6/100, moves: 5, ncost: 2460.603639695213
Run: 9, iteration: 7/100, moves: 12, ncost: 2456.461210115341
Run: 9, iteration: 8/100, moves: 9, ncost: 2454.321517696691
Run: 9, iteration: 9/100, moves: 3, ncost: 2453.7197307490705
Run: 9, iteration: 10/100, moves: 3, ncost: 2453.308544832501
Run: 9, iteration: 11/100, moves: 4, ncost: 2452.460402418397
Run: 9, iteration: 12/100, moves: 9, ncost: 2450.982358702392
Run: 9, iteration: 13/100, moves: 0, ncost: 2450.982358702392
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 10, iteration: 1/100, moves: 229, ncost: 2725.417624570084
Run: 10, iteration: 2/100, moves: 104, ncost: 2622.829653773603
Run: 10, iteration: 3/100, moves: 68, ncost: 2515.683455976393
Run: 10, iteration: 4/100, moves: 54, ncost: 2400.7689628144194
Run: 10, iteration: 5/100, moves: 28, ncost: 2386.0583839832193
Run: 10, iteration: 6/100, moves: 5, ncost: 2384.902877948216
Run: 10, iteration: 7/100, moves: 3, ncost: 2384.3786539200855
Run: 10, iteration: 8/100, moves: 8, ncost: 2382.533830818127
Run: 10, iteration: 9/100, moves: 3, ncost: 2381.228143329528
Run: 10, iteration: 10/100, moves: 10, ncost: 2377.4686478422773
Run: 10, iteration: 11/100, moves: 5, ncost: 2375.8658327645085
Run: 10, iteration: 12/100, moves: 9, ncost: 2369.930082214109
Run: 10, iteration: 13/100, moves: 11, ncost: 2363.4299890601283
Run: 10, iteration: 14/100, moves: 17, ncost: 2351.9598375607006
Run: 10, iteration: 15/100, moves: 12, ncost: 2345.5088134063576
Run: 10, iteration: 16/100, moves: 16, ncost: 2335.959292849587
Run: 10, iteration: 17/100, moves: 15, ncost: 2328.4028644208697
18%|██████████|
| 5/28 [00:16<01:19, 3.46s/it]
```

```
Run: 10, iteration: 18/100, moves: 1, ncost: 2328.211875342115
Run: 10, iteration: 19/100, moves: 1, ncost: 2327.9916231271
Run: 10, iteration: 20/100, moves: 1, ncost: 2327.793849619139
Run: 10, iteration: 21/100, moves: 0, ncost: 2327.793849619139
Best run was number 10
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 1, iteration: 1/100, moves: 156, ncost: 2345.6851655309965
Run: 1, iteration: 2/100, moves: 76, ncost: 2241.4438044804765
Run: 1, iteration: 3/100, moves: 32, ncost: 2222.867522369947
Run: 1, iteration: 4/100, moves: 11, ncost: 2219.5227260525726
Run: 1, iteration: 5/100, moves: 10, ncost: 2215.5081479003184
Run: 1, iteration: 6/100, moves: 8, ncost: 2212.480622870226
Run: 1, iteration: 7/100, moves: 8, ncost: 2210.0473877550994
Run: 1, iteration: 8/100, moves: 1, ncost: 2209.8789874574727
Run: 1, iteration: 9/100, moves: 0, ncost: 2209.8789874574727
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 2, iteration: 1/100, moves: 184, ncost: 2416.994568062051
Run: 2, iteration: 2/100, moves: 76, ncost: 2328.2447793043016
Run: 2, iteration: 3/100, moves: 60, ncost: 2272.5364299271305
Run: 2, iteration: 4/100, moves: 34, ncost: 2247.2082679269597
Run: 2, iteration: 5/100, moves: 21, ncost: 2239.8686084269366
Run: 2, iteration: 6/100, moves: 7, ncost: 2237.86213655773
Run: 2, iteration: 7/100, moves: 15, ncost: 2233.7085839145307
Run: 2, iteration: 8/100, moves: 10, ncost: 2228.880315544239
Run: 2, iteration: 9/100, moves: 14, ncost: 2220.960529855651
Run: 2, iteration: 10/100, moves: 23, ncost: 2199.1310246671082
Run: 2, iteration: 11/100, moves: 16, ncost: 2191.979000655305
Run: 2, iteration: 12/100, moves: 8, ncost: 2187.4312388791836
Run: 2, iteration: 13/100, moves: 14, ncost: 2181.7440306692224
Run: 2, iteration: 14/100, moves: 14, ncost: 2175.144838522625
Run: 2, iteration: 15/100, moves: 9, ncost: 2172.1705093636037
Run: 2, iteration: 16/100, moves: 6, ncost: 2169.6556680563986
Run: 2, iteration: 17/100, moves: 0, ncost: 2169.6556680563986
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 3, iteration: 1/100, moves: 178, ncost: 2195.8680643666066
Run: 3, iteration: 2/100, moves: 39, ncost: 2171.36608386747
Run: 3, iteration: 3/100, moves: 7, ncost: 2169.7092793998318
Run: 3, iteration: 4/100, moves: 0, ncost: 2169.7092793998318
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 4, iteration: 1/100, moves: 259, ncost: 2295.5838193970403
Run: 4, iteration: 2/100, moves: 66, ncost: 2249.2486975622533
Run: 4, iteration: 3/100, moves: 25, ncost: 2233.325109765962
Run: 4, iteration: 4/100, moves: 20, ncost: 2223.403650398619
Run: 4, iteration: 5/100, moves: 19, ncost: 2215.619843386334
Run: 4, iteration: 6/100, moves: 13, ncost: 2209.107218993384
Run: 4, iteration: 7/100, moves: 9, ncost: 2204.897652558496
Run: 4, iteration: 8/100, moves: 16, ncost: 2193.3300628232064
Run: 4, iteration: 9/100, moves: 19, ncost: 2181.7618499991145
Run: 4, iteration: 10/100, moves: 7, ncost: 2180.7733473280828
```

Run: 4, iteration: 11/100, moves: 2, ncost: 2180.4456351747813  
Run: 4, iteration: 12/100, moves: 2, ncost: 2180.0165601502877  
Run: 4, iteration: 13/100, moves: 4, ncost: 2177.352798392048  
Run: 4, iteration: 14/100, moves: 9, ncost: 2172.2424301887754  
Run: 4, iteration: 15/100, moves: 1, ncost: 2172.1154676200513  
Run: 4, iteration: 16/100, moves: 0, ncost: 2172.1154676200513  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 5, iteration: 1/100, moves: 203, ncost: 2572.374387206168  
Run: 5, iteration: 2/100, moves: 110, ncost: 2442.617983109578  
Run: 5, iteration: 3/100, moves: 86, ncost: 2223.6919877439736  
Run: 5, iteration: 4/100, moves: 35, ncost: 2199.608201647957  
Run: 5, iteration: 5/100, moves: 13, ncost: 2193.9768351507414  
Run: 5, iteration: 6/100, moves: 7, ncost: 2191.0696568630096  
Run: 5, iteration: 7/100, moves: 1, ncost: 2190.9461912226643  
Run: 5, iteration: 8/100, moves: 0, ncost: 2190.9461912226643  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 6, iteration: 1/100, moves: 218, ncost: 2348.9243765022165  
Run: 6, iteration: 2/100, moves: 85, ncost: 2294.742129250344  
Run: 6, iteration: 3/100, moves: 25, ncost: 2284.156257922411  
Run: 6, iteration: 4/100, moves: 10, ncost: 2280.292391309629  
Run: 6, iteration: 5/100, moves: 17, ncost: 2269.526185315874  
Run: 6, iteration: 6/100, moves: 36, ncost: 2242.6512396008584  
Run: 6, iteration: 7/100, moves: 19, ncost: 2237.2925568733776  
Run: 6, iteration: 8/100, moves: 3, ncost: 2236.6764073335753  
Run: 6, iteration: 9/100, moves: 8, ncost: 2234.076231155482  
Run: 6, iteration: 10/100, moves: 1, ncost: 2233.8926444483263  
Run: 6, iteration: 11/100, moves: 2, ncost: 2233.586798632955  
Run: 6, iteration: 12/100, moves: 0, ncost: 2233.586798632955  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 7, iteration: 1/100, moves: 227, ncost: 2622.622449248346  
Run: 7, iteration: 2/100, moves: 133, ncost: 2320.1411082084282  
Run: 7, iteration: 3/100, moves: 75, ncost: 2222.6743812827967  
Run: 7, iteration: 4/100, moves: 19, ncost: 2217.0763507677466  
Run: 7, iteration: 5/100, moves: 5, ncost: 2216.454166325082  
Run: 7, iteration: 6/100, moves: 4, ncost: 2215.6802850407726  
Run: 7, iteration: 7/100, moves: 2, ncost: 2215.5302870804953  
Run: 7, iteration: 8/100, moves: 0, ncost: 2215.5302870804953  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 8, iteration: 1/100, moves: 220, ncost: 2613.2557867422347  
Run: 8, iteration: 2/100, moves: 123, ncost: 2368.2825992009316  
Run: 8, iteration: 3/100, moves: 66, ncost: 2297.796443246131  
Run: 8, iteration: 4/100, moves: 37, ncost: 2277.3985374203107  
Run: 8, iteration: 5/100, moves: 26, ncost: 2266.90580151829  
Run: 8, iteration: 6/100, moves: 17, ncost: 2260.611302614691  
Run: 8, iteration: 7/100, moves: 11, ncost: 2256.678274279029  
Run: 8, iteration: 8/100, moves: 10, ncost: 2253.2347902218426

```
Run: 8, iteration: 9/100, moves: 8, ncost: 2250.3583847531963
Run: 8, iteration: 10/100, moves: 6, ncost: 2246.341582117788
Run: 8, iteration: 11/100, moves: 19, ncost: 2231.832019275301
Run: 8, iteration: 12/100, moves: 8, ncost: 2228.513241321597
Run: 8, iteration: 13/100, moves: 9, ncost: 2226.0029732657767
Run: 8, iteration: 14/100, moves: 6, ncost: 2224.4522089543325
Run: 8, iteration: 15/100, moves: 3, ncost: 2224.0184000128465
Run: 8, iteration: 16/100, moves: 1, ncost: 2223.987231517914
Run: 8, iteration: 17/100, moves: 0, ncost: 2223.987231517914
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 232, ncost: 2368.9677754109202
Run: 9, iteration: 2/100, moves: 96, ncost: 2267.2142150421473
Run: 9, iteration: 3/100, moves: 23, ncost: 2257.146507287874
Run: 9, iteration: 4/100, moves: 7, ncost: 2255.5865282632535
Run: 9, iteration: 5/100, moves: 6, ncost: 2254.2067857048164
Run: 9, iteration: 6/100, moves: 6, ncost: 2251.2975921325037
Run: 9, iteration: 7/100, moves: 4, ncost: 2250.908067948799
Run: 9, iteration: 8/100, moves: 0, ncost: 2250.908067948799
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 10, iteration: 1/100, moves: 267, ncost: 2422.6357885723937
Run: 10, iteration: 2/100, moves: 90, ncost: 2232.9900492365978
Run: 10, iteration: 3/100, moves: 10, ncost: 2227.607657821715
Run: 10, iteration: 4/100, moves: 2, ncost: 2227.2457304267964
Run: 10, iteration: 5/100, moves: 0, ncost: 2227.2457304267964
Best run was number 2
```

21%|███████████  
6/28 [00:20<01:20, 3.66s/it]

Initialization method and algorithm are deterministic. Setting n\_init to 1.

Init: initializing centroids  
Init: initializing clusters  
Starting iterations...

Run: 1, iteration: 1/100, moves: 191, ncost: 2471.866680083722  
Run: 1, iteration: 2/100, moves: 94, ncost: 2259.317004562896  
Run: 1, iteration: 3/100, moves: 37, ncost: 2180.9850257176754  
Run: 1, iteration: 4/100, moves: 15, ncost: 2160.3606521106826  
Run: 1, iteration: 5/100, moves: 4, ncost: 2157.280391237479  
Run: 1, iteration: 6/100, moves: 2, ncost: 2156.425780400973  
Run: 1, iteration: 7/100, moves: 0, ncost: 2156.425780400973  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...

Run: 2, iteration: 1/100, moves: 209, ncost: 2307.784298902759  
Run: 2, iteration: 2/100, moves: 95, ncost: 2177.3574267629447  
Run: 2, iteration: 3/100, moves: 38, ncost: 2158.0373149694233  
Run: 2, iteration: 4/100, moves: 17, ncost: 2151.1085245733143  
Run: 2, iteration: 5/100, moves: 15, ncost: 2146.8392675261284  
Run: 2, iteration: 6/100, moves: 8, ncost: 2145.4868652203145  
Run: 2, iteration: 7/100, moves: 1, ncost: 2145.3945741869325  
Run: 2, iteration: 8/100, moves: 0, ncost: 2145.3945741869325  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...

Run: 3, iteration: 1/100, moves: 189, ncost: 2270.5555654847367  
Run: 3, iteration: 2/100, moves: 82, ncost: 2204.3789423974313  
Run: 3, iteration: 3/100, moves: 41, ncost: 2180.9771088297734  
Run: 3, iteration: 4/100, moves: 14, ncost: 2177.004684602924  
Run: 3, iteration: 5/100, moves: 1, ncost: 2176.848932312555  
Run: 3, iteration: 6/100, moves: 0, ncost: 2176.848932312555  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...

Run: 4, iteration: 1/100, moves: 271, ncost: 2317.307506209104  
Run: 4, iteration: 2/100, moves: 82, ncost: 2202.9384040210025  
Run: 4, iteration: 3/100, moves: 60, ncost: 2132.9895878302523  
Run: 4, iteration: 4/100, moves: 37, ncost: 2111.366627128482  
Run: 4, iteration: 5/100, moves: 13, ncost: 2105.8269610692437  
Run: 4, iteration: 6/100, moves: 6, ncost: 2103.2850932614033  
Run: 4, iteration: 7/100, moves: 12, ncost: 2099.1948917616564  
Run: 4, iteration: 8/100, moves: 0, ncost: 2099.1948917616564  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...

Run: 5, iteration: 1/100, moves: 192, ncost: 2211.1495600192097  
Run: 5, iteration: 2/100, moves: 85, ncost: 2099.0128609292665  
Run: 5, iteration: 3/100, moves: 26, ncost: 2083.9589734463393  
Run: 5, iteration: 4/100, moves: 5, ncost: 2083.053152559648  
Run: 5, iteration: 5/100, moves: 1, ncost: 2082.9265027492934  
Run: 5, iteration: 6/100, moves: 0, ncost: 2082.9265027492934  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...

Run: 6, iteration: 1/100, moves: 264, ncost: 2281.277551201472  
Run: 6, iteration: 2/100, moves: 108, ncost: 2179.6264377429466  
Run: 6, iteration: 3/100, moves: 37, ncost: 2158.945644989387  
Run: 6, iteration: 4/100, moves: 17, ncost: 2153.608333307934

```
Run: 6, iteration: 5/100, moves: 4, ncost: 2152.954443239156
Run: 6, iteration: 6/100, moves: 1, ncost: 2152.898627606572
Run: 6, iteration: 7/100, moves: 0, ncost: 2152.898627606572
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 210, ncost: 2248.2524368273052
Run: 7, iteration: 2/100, moves: 102, ncost: 2116.353513173929
Run: 7, iteration: 3/100, moves: 53, ncost: 2070.3074776432136
Run: 7, iteration: 4/100, moves: 10, ncost: 2068.6466737375736
Run: 7, iteration: 5/100, moves: 0, ncost: 2068.6466737375736
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 230, ncost: 2271.4147650591417
Run: 8, iteration: 2/100, moves: 93, ncost: 2183.9323234726144
Run: 8, iteration: 3/100, moves: 60, ncost: 2122.434572624891
Run: 8, iteration: 4/100, moves: 30, ncost: 2108.854729679121
Run: 8, iteration: 5/100, moves: 16, ncost: 2097.393068741463
Run: 8, iteration: 6/100, moves: 25, ncost: 2072.837153471093
Run: 8, iteration: 7/100, moves: 16, ncost: 2066.317302271822
Run: 8, iteration: 8/100, moves: 3, ncost: 2065.6247706902823
Run: 8, iteration: 9/100, moves: 0, ncost: 2065.6247706902823
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 235, ncost: 2246.452868517962
Run: 9, iteration: 2/100, moves: 60, ncost: 2201.301364687294
Run: 9, iteration: 3/100, moves: 19, ncost: 2190.7278581579094
Run: 9, iteration: 4/100, moves: 20, ncost: 2173.5004657630548
Run: 9, iteration: 5/100, moves: 8, ncost: 2171.0717327575794
Run: 9, iteration: 6/100, moves: 2, ncost: 2170.6516542634877
Run: 9, iteration: 7/100, moves: 0, ncost: 2170.6516542634877
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 10, iteration: 1/100, moves: 227, ncost: 2264.663139933765
Run: 10, iteration: 2/100, moves: 75, ncost: 2208.979946945511
Run: 10, iteration: 3/100, moves: 36, ncost: 2188.294417423751
Run: 10, iteration: 4/100, moves: 28, ncost: 2176.0441083079736
Run: 10, iteration: 5/100, moves: 21, ncost: 2160.977427730537
Run: 10, iteration: 6/100, moves: 26, ncost: 2144.543773468663
Run: 10, iteration: 7/100, moves: 16, ncost: 2139.3168894137734
Run: 10, iteration: 8/100, moves: 5, ncost: 2138.4310093173654
Run: 10, iteration: 9/100, moves: 1, ncost: 2138.313646189608
```

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25%|████████████████████████████████████████|
| 7/28 [00:23<01:13, 3.49s/it]
```

```
Run: 10, iteration: 10/100, moves: 0, ncost: 2138.313646189608
Best run was number 8
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 1, iteration: 1/100, moves: 156, ncost: 2222.389177744337
Run: 1, iteration: 2/100, moves: 70, ncost: 2135.9573552778857
Run: 1, iteration: 3/100, moves: 31, ncost: 2118.2803788313686
Run: 1, iteration: 4/100, moves: 27, ncost: 2101.8871200846047
Run: 1, iteration: 5/100, moves: 30, ncost: 2077.503574239824
Run: 1, iteration: 6/100, moves: 20, ncost: 2066.214241612235
Run: 1, iteration: 7/100, moves: 16, ncost: 2059.938176334295
Run: 1, iteration: 8/100, moves: 12, ncost: 2053.057427537317
Run: 1, iteration: 9/100, moves: 14, ncost: 2046.0085018139412
Run: 1, iteration: 10/100, moves: 3, ncost: 2045.5364095622033
Run: 1, iteration: 11/100, moves: 3, ncost: 2044.4982530672526
Run: 1, iteration: 12/100, moves: 10, ncost: 2039.9960266434614
Run: 1, iteration: 13/100, moves: 8, ncost: 2038.1757136113126
Run: 1, iteration: 14/100, moves: 1, ncost: 2038.018292384016
Run: 1, iteration: 15/100, moves: 0, ncost: 2038.018292384016
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 2, iteration: 1/100, moves: 220, ncost: 2259.499829973782
Run: 2, iteration: 2/100, moves: 81, ncost: 2153.167991664839
Run: 2, iteration: 3/100, moves: 64, ncost: 2095.0047623717164
Run: 2, iteration: 4/100, moves: 47, ncost: 2059.919883209327
Run: 2, iteration: 5/100, moves: 26, ncost: 2044.3532713673978
Run: 2, iteration: 6/100, moves: 15, ncost: 2036.4460172964832
Run: 2, iteration: 7/100, moves: 11, ncost: 2032.5544740742741
Run: 2, iteration: 8/100, moves: 1, ncost: 2032.3992260150633
Run: 2, iteration: 9/100, moves: 0, ncost: 2032.3992260150633
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 3, iteration: 1/100, moves: 193, ncost: 2225.5476745851156
Run: 3, iteration: 2/100, moves: 90, ncost: 2113.2600066651426
Run: 3, iteration: 3/100, moves: 64, ncost: 2039.1798665446393
Run: 3, iteration: 4/100, moves: 35, ncost: 2006.9424898424334
Run: 3, iteration: 5/100, moves: 14, ncost: 2000.7758506362272
Run: 3, iteration: 6/100, moves: 1, ncost: 2000.6272078811269
Run: 3, iteration: 7/100, moves: 0, ncost: 2000.6272078811269
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 4, iteration: 1/100, moves: 163, ncost: 2274.12025862563
Run: 4, iteration: 2/100, moves: 49, ncost: 2224.6701716232906
Run: 4, iteration: 3/100, moves: 29, ncost: 2202.0860567883633
Run: 4, iteration: 4/100, moves: 32, ncost: 2152.5761475597037
Run: 4, iteration: 5/100, moves: 64, ncost: 2026.217994677025
Run: 4, iteration: 6/100, moves: 27, ncost: 2011.3617966835398
Run: 4, iteration: 7/100, moves: 8, ncost: 2009.372792911786
Run: 4, iteration: 8/100, moves: 1, ncost: 2009.3051258090693
Run: 4, iteration: 9/100, moves: 0, ncost: 2009.3051258090693
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 5, iteration: 1/100, moves: 188, ncost: 2186.8666890217582
Run: 5, iteration: 2/100, moves: 70, ncost: 2128.6134588739933
```



```
Run: 5, iteration: 3/100, moves: 19, ncost: 2110.246835952414
Run: 5, iteration: 4/100, moves: 23, ncost: 2063.5251001312504
Run: 5, iteration: 5/100, moves: 33, ncost: 2019.6248560847669
Run: 5, iteration: 6/100, moves: 22, ncost: 2009.964192529817
Run: 5, iteration: 7/100, moves: 18, ncost: 1999.9194782911559
Run: 5, iteration: 8/100, moves: 10, ncost: 1996.1898514253485
Run: 5, iteration: 9/100, moves: 4, ncost: 1995.588703321469
Run: 5, iteration: 10/100, moves: 0, ncost: 1995.588703321469
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 193, ncost: 2163.9282051677533
Run: 6, iteration: 2/100, moves: 72, ncost: 2091.3382926916447
Run: 6, iteration: 3/100, moves: 47, ncost: 2034.501814473071
Run: 6, iteration: 4/100, moves: 16, ncost: 2027.189694965237
Run: 6, iteration: 5/100, moves: 6, ncost: 2026.0707438774489
Run: 6, iteration: 6/100, moves: 4, ncost: 2025.3382013253736
Run: 6, iteration: 7/100, moves: 5, ncost: 2024.0839904976503
Run: 6, iteration: 8/100, moves: 3, ncost: 2023.684960255789
Run: 6, iteration: 9/100, moves: 3, ncost: 2023.1962296640525
Run: 6, iteration: 10/100, moves: 0, ncost: 2023.1962296640525
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 262, ncost: 2155.5074086449767
Run: 7, iteration: 2/100, moves: 82, ncost: 2059.237873188579
Run: 7, iteration: 3/100, moves: 42, ncost: 2037.038664104965
Run: 7, iteration: 4/100, moves: 15, ncost: 2029.2452125361033
Run: 7, iteration: 5/100, moves: 13, ncost: 2025.1357276440535
Run: 7, iteration: 6/100, moves: 13, ncost: 2016.7707246574573
Run: 7, iteration: 7/100, moves: 18, ncost: 2003.423818695542
Run: 7, iteration: 8/100, moves: 10, ncost: 1999.9136302076954
Run: 7, iteration: 9/100, moves: 8, ncost: 1997.6224501749268
Run: 7, iteration: 10/100, moves: 5, ncost: 1996.9876860799493
Run: 7, iteration: 11/100, moves: 3, ncost: 1996.0147456147083
Run: 7, iteration: 12/100, moves: 2, ncost: 1995.7610267268096
Run: 7, iteration: 13/100, moves: 0, ncost: 1995.7610267268096
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 205, ncost: 2078.3219941684324
Run: 8, iteration: 2/100, moves: 67, ncost: 2000.6250611235025
Run: 8, iteration: 3/100, moves: 26, ncost: 1984.2055412806783
Run: 8, iteration: 4/100, moves: 9, ncost: 1982.4102783592696
Run: 8, iteration: 5/100, moves: 4, ncost: 1980.9359775625715
Run: 8, iteration: 6/100, moves: 2, ncost: 1980.7996774864316
Run: 8, iteration: 7/100, moves: 0, ncost: 1980.7996774864316
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 226, ncost: 2197.1783126876708
Run: 9, iteration: 2/100, moves: 73, ncost: 2145.4108581099126
Run: 9, iteration: 3/100, moves: 29, ncost: 2135.749926706526
Run: 9, iteration: 4/100, moves: 26, ncost: 2117.533857196336
Run: 9, iteration: 5/100, moves: 24, ncost: 2091.307977940547
Run: 9, iteration: 6/100, moves: 36, ncost: 2055.716467935467
Run: 9, iteration: 7/100, moves: 14, ncost: 2050.454166810756
Run: 9, iteration: 8/100, moves: 6, ncost: 2048.4863201220614
Run: 9, iteration: 9/100, moves: 8, ncost: 2045.3170186259165
Run: 9, iteration: 10/100, moves: 16, ncost: 2037.5815124078495
```

```
29%|███████████  
| 8/28 [00:28<01:15, 3.80s/it]
```

```
Run: 10, iteration: 4/100, moves: 53, ncost: 2027.6770902127455
Run: 10, iteration: 5/100, moves: 27, ncost: 2012.8146438595124
Run: 10, iteration: 6/100, moves: 8, ncost: 2011.654002351474
Run: 10, iteration: 7/100, moves: 0, ncost: 2011.654002351474
Best run was number 8
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 1, iteration: 1/100, moves: 244, ncost: 2088.8044474935286
Run: 1, iteration: 2/100, moves: 93, ncost: 1994.599857683471
Run: 1, iteration: 3/100, moves: 23, ncost: 1976.0841308776246
Run: 1, iteration: 4/100, moves: 18, ncost: 1965.8787538472366
Run: 1, iteration: 5/100, moves: 9, ncost: 1963.72039692096
Run: 1, iteration: 6/100, moves: 2, ncost: 1963.0153498680518
Run: 1, iteration: 7/100, moves: 3, ncost: 1962.4657478450074
Run: 1, iteration: 8/100, moves: 1, ncost: 1962.246880019645
Run: 1, iteration: 9/100, moves: 2, ncost: 1961.9025727875953
Run: 1, iteration: 10/100, moves: 1, ncost: 1961.7464242707208
Run: 1, iteration: 11/100, moves: 0, ncost: 1961.7464242707208
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 2, iteration: 1/100, moves: 269, ncost: 2040.1351819349181
Run: 2, iteration: 2/100, moves: 91, ncost: 1933.9460393603151
Run: 2, iteration: 3/100, moves: 32, ncost: 1915.7539436272
Run: 2, iteration: 4/100, moves: 12, ncost: 1911.7690748157138
Run: 2, iteration: 5/100, moves: 3, ncost: 1911.0890372086376
Run: 2, iteration: 6/100, moves: 0, ncost: 1911.0890372086376
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 3, iteration: 1/100, moves: 237, ncost: 2088.1175196384743
Run: 3, iteration: 2/100, moves: 90, ncost: 2003.8900513496635
Run: 3, iteration: 3/100, moves: 58, ncost: 1961.716428138733
Run: 3, iteration: 4/100, moves: 28, ncost: 1945.0049595343978
Run: 3, iteration: 5/100, moves: 21, ncost: 1937.5162373908613
Run: 3, iteration: 6/100, moves: 3, ncost: 1937.1938037538337
Run: 3, iteration: 7/100, moves: 1, ncost: 1937.1285251968618
Run: 3, iteration: 8/100, moves: 0, ncost: 1937.1285251968618
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 4, iteration: 1/100, moves: 284, ncost: 2122.5360422146823
Run: 4, iteration: 2/100, moves: 102, ncost: 2017.5290330506043
Run: 4, iteration: 3/100, moves: 38, ncost: 1993.6154228937746
Run: 4, iteration: 4/100, moves: 39, ncost: 1961.9827285697077
Run: 4, iteration: 5/100, moves: 30, ncost: 1940.4055412906068
Run: 4, iteration: 6/100, moves: 23, ncost: 1924.6020254729558
Run: 4, iteration: 7/100, moves: 14, ncost: 1918.6576571004198
```

```
Run: 4, iteration: 8/100, moves: 4, ncost: 1917.3974375669964
Run: 4, iteration: 9/100, moves: 2, ncost: 1917.1105746482056
Run: 4, iteration: 10/100, moves: 0, ncost: 1917.1105746482056
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 5, iteration: 1/100, moves: 253, ncost: 2053.9045930206953
Run: 5, iteration: 2/100, moves: 101, ncost: 1945.2003518401107
Run: 5, iteration: 3/100, moves: 22, ncost: 1935.3002184314207
Run: 5, iteration: 4/100, moves: 10, ncost: 1931.4559209140668
Run: 5, iteration: 5/100, moves: 9, ncost: 1927.3794504565167
Run: 5, iteration: 6/100, moves: 16, ncost: 1913.89897745034
Run: 5, iteration: 7/100, moves: 19, ncost: 1894.430351617858
Run: 5, iteration: 8/100, moves: 14, ncost: 1887.0520391463172
Run: 5, iteration: 9/100, moves: 2, ncost: 1886.7178224209385
Run: 5, iteration: 10/100, moves: 1, ncost: 1886.6509452525938
Run: 5, iteration: 11/100, moves: 0, ncost: 1886.6509452525938
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 262, ncost: 2095.2722853730947
Run: 6, iteration: 2/100, moves: 66, ncost: 2038.9068531928551
Run: 6, iteration: 3/100, moves: 38, ncost: 2012.7079247148722
Run: 6, iteration: 4/100, moves: 22, ncost: 1999.1956164526682
Run: 6, iteration: 5/100, moves: 28, ncost: 1967.8020521018352
Run: 6, iteration: 6/100, moves: 20, ncost: 1955.9521250828025
Run: 6, iteration: 7/100, moves: 14, ncost: 1949.327084000603
Run: 6, iteration: 8/100, moves: 11, ncost: 1940.8012795357533
Run: 6, iteration: 9/100, moves: 5, ncost: 1938.77687189945
Run: 6, iteration: 10/100, moves: 1, ncost: 1938.6352841179616
Run: 6, iteration: 11/100, moves: 2, ncost: 1938.4282675316392
Run: 6, iteration: 12/100, moves: 0, ncost: 1938.4282675316392
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 226, ncost: 2046.6430920659946
Run: 7, iteration: 2/100, moves: 96, ncost: 1952.4180743537593
Run: 7, iteration: 3/100, moves: 32, ncost: 1939.302944047935
Run: 7, iteration: 4/100, moves: 11, ncost: 1937.0722765665025
Run: 7, iteration: 5/100, moves: 14, ncost: 1928.8776413873004
Run: 7, iteration: 6/100, moves: 17, ncost: 1920.706457129553
Run: 7, iteration: 7/100, moves: 13, ncost: 1915.487240011489
Run: 7, iteration: 8/100, moves: 10, ncost: 1913.3991878710995
Run: 7, iteration: 9/100, moves: 3, ncost: 1912.8473783155514
Run: 7, iteration: 10/100, moves: 0, ncost: 1912.8473783155514
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 245, ncost: 2029.5245065719594
Run: 8, iteration: 2/100, moves: 67, ncost: 1972.1439810135685
Run: 8, iteration: 3/100, moves: 23, ncost: 1957.4792352492168
Run: 8, iteration: 4/100, moves: 8, ncost: 1953.274574042314
Run: 8, iteration: 5/100, moves: 6, ncost: 1951.0702138811148
Run: 8, iteration: 6/100, moves: 1, ncost: 1950.9015124648538
Run: 8, iteration: 7/100, moves: 0, ncost: 1950.9015124648538
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 223, ncost: 2059.8737764684406
Run: 9, iteration: 2/100, moves: 62, ncost: 2025.4669923504428
```

```
32%|███████████|  
9/28 [00:32<01:15, 3.95s/it]
```

Initialization method and algorithm are deterministic. Setting n\_init to 1.

Init: initializing centroids

Init: initializing clusters

Starting iterations...

Run: 1, iteration: 1/100, moves: 199, ncost: 2005.9182827062941

Run: 1, iteration: 2/100, moves: 80, ncost: 1919.3177704701293

Run: 1, iteration: 3/100, moves: 54, ncost: 1877.6463189191345

Run: 1, iteration: 4/100, moves: 13, ncost: 1873.4686245280857

Run: 1, iteration: 5/100, moves: 4, ncost: 1872.8701110476486

Run: 1, iteration: 6/100, moves: 0, ncost: 1872.8701110476486

Init: initializing centroids

Init: initializing clusters

Starting iterations...

Run: 2, iteration: 1/100, moves: 240, ncost: 2006.1173543341024

Run: 2, iteration: 2/100, moves: 80, ncost: 1952.8012380815876

Run: 2, iteration: 3/100, moves: 24, ncost: 1942.0718925245571

Run: 2, iteration: 4/100, moves: 16, ncost: 1933.391209468016

Run: 2, iteration: 5/100, moves: 5, ncost: 1931.463797962689

Run: 2, iteration: 6/100, moves: 14, ncost: 1923.5529070285563

Run: 2, iteration: 7/100, moves: 12, ncost: 1918.6586487607294

Run: 2, iteration: 8/100, moves: 7, ncost: 1916.7586692506984

Run: 2, iteration: 9/100, moves: 5, ncost: 1915.8753198639345

Run: 2, iteration: 10/100, moves: 1, ncost: 1915.759363847164

Run: 2, iteration: 11/100, moves: 0, ncost: 1915.759363847164

Init: initializing centroids

Init: initializing clusters

Starting iterations...

Run: 3, iteration: 1/100, moves: 183, ncost: 2005.4270691800753

Run: 3, iteration: 2/100, moves: 73, ncost: 1925.8932592299595

Run: 3, iteration: 3/100, moves: 54, ncost: 1883.9320175571725

Run: 3, iteration: 4/100, moves: 32, ncost: 1856.2879890634958

Run: 3, iteration: 5/100, moves: 24, ncost: 1845.8696435833176

Run: 3, iteration: 6/100, moves: 16, ncost: 1838.5750135079052

Run: 3, iteration: 7/100, moves: 12, ncost: 1830.418628472082

Run: 3, iteration: 8/100, moves: 8, ncost: 1827.8031029657327

Run: 3, iteration: 9/100, moves: 4, ncost: 1826.004080950988

Run: 3, iteration: 10/100, moves: 6, ncost: 1824.7805314109864

Run: 3, iteration: 11/100, moves: 0, ncost: 1824.7805314109864

Init: initializing centroids

Init: initializing clusters

Starting iterations...

Run: 4, iteration: 1/100, moves: 229, ncost: 2013.3944523877024

Run: 4, iteration: 2/100, moves: 81, ncost: 1939.5876252246403

Run: 4, iteration: 3/100, moves: 57, ncost: 1898.933068267157

Run: 4, iteration: 4/100, moves: 35, ncost: 1881.7654011058135

Run: 4, iteration: 5/100, moves: 9, ncost: 1879.9189429694177

Run: 4, iteration: 6/100, moves: 0, ncost: 1879.9189429694177

Init: initializing centroids

Init: initializing clusters

Starting iterations...

Run: 5, iteration: 1/100, moves: 254, ncost: 2045.143651941096

Run: 5, iteration: 2/100, moves: 97, ncost: 1964.501525488463

Run: 5, iteration: 3/100, moves: 46, ncost: 1941.822385446875

Run: 5, iteration: 4/100, moves: 22, ncost: 1929.2369474920702

Run: 5, iteration: 5/100, moves: 20, ncost: 1919.3087783649382

Run: 5, iteration: 6/100, moves: 20, ncost: 1911.7703289110104

Run: 5, iteration: 7/100, moves: 12, ncost: 1907.7002924765447

Run: 5, iteration: 8/100, moves: 8, ncost: 1904.4841832379843

Run: 5, iteration: 9/100, moves: 13, ncost: 1900.6693363965098

Run: 5, iteration: 10/100, moves: 7, ncost: 1898.4178056350074

```
Run: 5, iteration: 11/100, moves: 2, ncost: 1898.236152475444
Run: 5, iteration: 12/100, moves: 1, ncost: 1898.0766497944876
Run: 5, iteration: 13/100, moves: 1, ncost: 1897.8703587856614
Run: 5, iteration: 14/100, moves: 0, ncost: 1897.8703587856614
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 272, ncost: 2077.8087537522288
Run: 6, iteration: 2/100, moves: 104, ncost: 1965.0419798619268
Run: 6, iteration: 3/100, moves: 61, ncost: 1889.7693953497383
Run: 6, iteration: 4/100, moves: 46, ncost: 1851.1711532306483
Run: 6, iteration: 5/100, moves: 18, ncost: 1840.9267694890991
Run: 6, iteration: 6/100, moves: 9, ncost: 1836.6833619602503
Run: 6, iteration: 7/100, moves: 12, ncost: 1829.8524973327767
Run: 6, iteration: 8/100, moves: 9, ncost: 1825.8245217210529
Run: 6, iteration: 9/100, moves: 3, ncost: 1825.0161472880484
Run: 6, iteration: 10/100, moves: 3, ncost: 1824.4691031649236
Run: 6, iteration: 11/100, moves: 1, ncost: 1824.1047541869395
Run: 6, iteration: 12/100, moves: 1, ncost: 1824.0341650836967
Run: 6, iteration: 13/100, moves: 0, ncost: 1824.0341650836967
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 206, ncost: 1928.3024194240115
Run: 7, iteration: 2/100, moves: 61, ncost: 1889.8710409009013
Run: 7, iteration: 3/100, moves: 23, ncost: 1878.8094571814327
Run: 7, iteration: 4/100, moves: 13, ncost: 1872.4726171959098
Run: 7, iteration: 5/100, moves: 22, ncost: 1858.865133665113
Run: 7, iteration: 6/100, moves: 14, ncost: 1850.1935503078555
Run: 7, iteration: 7/100, moves: 10, ncost: 1845.7605523909747
Run: 7, iteration: 8/100, moves: 10, ncost: 1840.7533300915763
Run: 7, iteration: 9/100, moves: 2, ncost: 1840.1281955500494
Run: 7, iteration: 10/100, moves: 0, ncost: 1840.1281955500494
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 172, ncost: 2008.4539968836073
Run: 8, iteration: 2/100, moves: 50, ncost: 1972.2622322894877
Run: 8, iteration: 3/100, moves: 21, ncost: 1954.179345860867
Run: 8, iteration: 4/100, moves: 11, ncost: 1949.0696841626448
Run: 8, iteration: 5/100, moves: 1, ncost: 1949.0336814167224
Run: 8, iteration: 6/100, moves: 0, ncost: 1949.0336814167224
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 240, ncost: 1943.2349127318812
Run: 9, iteration: 2/100, moves: 80, ncost: 1889.9747763481585
Run: 9, iteration: 3/100, moves: 29, ncost: 1862.4654722632324
Run: 9, iteration: 4/100, moves: 6, ncost: 1858.6769479512786
Run: 9, iteration: 5/100, moves: 0, ncost: 1858.6769479512786
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 10, iteration: 1/100, moves: 251, ncost: 2078.6432642043133
Run: 10, iteration: 2/100, moves: 105, ncost: 1937.3849294536067
```

```
Run: 10, iteration: 3/100, moves: 43, ncost: 1907.0127189473405
Run: 10, iteration: 4/100, moves: 24, ncost: 1887.2806965224609
```

```
| 10/28 [00:35<01:06, 3.69s/it]
```



```
Run: 10, iteration: 5/100, moves: 33, ncost: 1859.3465879557048
Run: 10, iteration: 6/100, moves: 22, ncost: 1845.7866701548717
Run: 10, iteration: 7/100, moves: 13, ncost: 1842.3672411751868
Run: 10, iteration: 8/100, moves: 4, ncost: 1841.317246603828
Run: 10, iteration: 9/100, moves: 0, ncost: 1841.317246603828
Best run was number 6
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 1, iteration: 1/100, moves: 236, ncost: 1936.5278071644943
Run: 1, iteration: 2/100, moves: 80, ncost: 1861.6522125656056
Run: 1, iteration: 3/100, moves: 31, ncost: 1841.1769403248722
Run: 1, iteration: 4/100, moves: 13, ncost: 1836.9536557015383
Run: 1, iteration: 5/100, moves: 10, ncost: 1832.6233378387412
Run: 1, iteration: 6/100, moves: 0, ncost: 1832.6233378387412
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 2, iteration: 1/100, moves: 239, ncost: 1916.087664990154
Run: 2, iteration: 2/100, moves: 71, ncost: 1850.2685342045402
Run: 2, iteration: 3/100, moves: 48, ncost: 1811.9921884939463
Run: 2, iteration: 4/100, moves: 26, ncost: 1798.9987904243983
Run: 2, iteration: 5/100, moves: 19, ncost: 1790.0623457273525
Run: 2, iteration: 6/100, moves: 16, ncost: 1781.6324177737697
Run: 2, iteration: 7/100, moves: 7, ncost: 1779.74685624673
Run: 2, iteration: 8/100, moves: 4, ncost: 1779.0529441409835
Run: 2, iteration: 9/100, moves: 1, ncost: 1778.9246727769396
Run: 2, iteration: 10/100, moves: 0, ncost: 1778.9246727769396
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 3, iteration: 1/100, moves: 235, ncost: 1926.597228734084
Run: 3, iteration: 2/100, moves: 72, ncost: 1850.9553229692167
Run: 3, iteration: 3/100, moves: 42, ncost: 1829.6116044563294
Run: 3, iteration: 4/100, moves: 17, ncost: 1822.5766167924673
Run: 3, iteration: 5/100, moves: 7, ncost: 1820.2635092130754
Run: 3, iteration: 6/100, moves: 5, ncost: 1817.1952539961192
Run: 3, iteration: 7/100, moves: 8, ncost: 1810.9981310326607
Run: 3, iteration: 8/100, moves: 14, ncost: 1803.2308625446829
Run: 3, iteration: 9/100, moves: 13, ncost: 1794.4480571961033
Run: 3, iteration: 10/100, moves: 8, ncost: 1792.468741682335
Run: 3, iteration: 11/100, moves: 3, ncost: 1791.9768748724775
Run: 3, iteration: 12/100, moves: 0, ncost: 1791.9768748724775
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 4, iteration: 1/100, moves: 225, ncost: 1864.6892306971326
Run: 4, iteration: 2/100, moves: 87, ncost: 1780.1806260716965
Run: 4, iteration: 3/100, moves: 25, ncost: 1771.660923330628
Run: 4, iteration: 4/100, moves: 10, ncost: 1768.3911783609356
Run: 4, iteration: 5/100, moves: 5, ncost: 1767.2663770931108
Run: 4, iteration: 6/100, moves: 5, ncost: 1766.4838499032637
Run: 4, iteration: 7/100, moves: 4, ncost: 1765.3370447517937
Run: 4, iteration: 8/100, moves: 4, ncost: 1764.4631282427836
Run: 4, iteration: 9/100, moves: 2, ncost: 1764.0539277735897
Run: 4, iteration: 10/100, moves: 0, ncost: 1764.0539277735897
Init: initializing centroids
Init: initializing clusters
Starting iterations...
```

```
Run: 5, iteration: 1/100, moves: 275, ncost: 1921.6374549423197
Run: 5, iteration: 2/100, moves: 65, ncost: 1874.7774355968768
Run: 5, iteration: 3/100, moves: 28, ncost: 1851.2942693850846
Run: 5, iteration: 4/100, moves: 24, ncost: 1834.2863939920674
Run: 5, iteration: 5/100, moves: 44, ncost: 1764.6512990303602
Run: 5, iteration: 6/100, moves: 15, ncost: 1758.245219265944
Run: 5, iteration: 7/100, moves: 7, ncost: 1756.3531386971572
Run: 5, iteration: 8/100, moves: 0, ncost: 1756.3531386971572
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 250, ncost: 1960.3044832049034
Run: 6, iteration: 2/100, moves: 96, ncost: 1883.1199882399235
Run: 6, iteration: 3/100, moves: 44, ncost: 1835.0466866371842
Run: 6, iteration: 4/100, moves: 28, ncost: 1801.9830522612826
Run: 6, iteration: 5/100, moves: 9, ncost: 1796.7755588640618
Run: 6, iteration: 6/100, moves: 6, ncost: 1795.5952298781203
Run: 6, iteration: 7/100, moves: 0, ncost: 1795.5952298781203
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 250, ncost: 1880.962992707574
Run: 7, iteration: 2/100, moves: 73, ncost: 1819.427716329904
Run: 7, iteration: 3/100, moves: 32, ncost: 1793.8387469548697
Run: 7, iteration: 4/100, moves: 16, ncost: 1788.9405708821112
Run: 7, iteration: 5/100, moves: 4, ncost: 1788.0360658849847
Run: 7, iteration: 6/100, moves: 3, ncost: 1787.438645795599
Run: 7, iteration: 7/100, moves: 0, ncost: 1787.438645795599
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 193, ncost: 1930.4818730618563
Run: 8, iteration: 2/100, moves: 89, ncost: 1819.457311441008
Run: 8, iteration: 3/100, moves: 34, ncost: 1776.9000348222323
Run: 8, iteration: 4/100, moves: 26, ncost: 1755.794381056698
Run: 8, iteration: 5/100, moves: 13, ncost: 1745.3609263892843
Run: 8, iteration: 6/100, moves: 9, ncost: 1740.6709063632336
Run: 8, iteration: 7/100, moves: 1, ncost: 1740.5394617584627
Run: 8, iteration: 8/100, moves: 0, ncost: 1740.5394617584627
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 184, ncost: 2043.1732147083417
Run: 9, iteration: 2/100, moves: 105, ncost: 1868.802299643239
Run: 9, iteration: 3/100, moves: 42, ncost: 1850.0221572921778
Run: 9, iteration: 4/100, moves: 23, ncost: 1838.326726045638
Run: 9, iteration: 5/100, moves: 6, ncost: 1835.8761885776305
Run: 9, iteration: 6/100, moves: 1, ncost: 1835.5693193534166
Run: 9, iteration: 7/100, moves: 2, ncost: 1835.247026422619
Run: 9, iteration: 8/100, moves: 2, ncost: 1835.0652533273146
Run: 9, iteration: 9/100, moves: 0, ncost: 1835.0652533273146
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 10, iteration: 1/100, moves: 218, ncost: 1956.3498286939002
Run: 10, iteration: 2/100, moves: 87, ncost: 1877.0768769031422
```

```
Run: 10, iteration: 3/100, moves: 49, ncost: 1797.1716150356692
Run: 10, iteration: 4/100, moves: 27, ncost: 1783.5260811448607
Run: 10, iteration: 5/100, moves: 2, ncost: 1783.1633471116158
Run: 10, iteration: 6/100, moves: 5, ncost: 1780.0821576871751
```

```
39%|███████████|  
| 11/28 [00:38<01:00, 3.59s/it]
```

```
Run: 10, iteration: 7/100, moves: 11, ncost: 1775.0110293051648
Run: 10, iteration: 8/100, moves: 6, ncost: 1773.8003410322797
Run: 10, iteration: 9/100, moves: 1, ncost: 1773.467802993478
Run: 10, iteration: 10/100, moves: 0, ncost: 1773.467802993478
Best run was number 8
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 1, iteration: 1/100, moves: 286, ncost: 1816.737680427098
Run: 1, iteration: 2/100, moves: 99, ncost: 1733.226340383958
Run: 1, iteration: 3/100, moves: 38, ncost: 1702.252486821136
Run: 1, iteration: 4/100, moves: 19, ncost: 1691.4995804675918
Run: 1, iteration: 5/100, moves: 9, ncost: 1689.675007427032
Run: 1, iteration: 6/100, moves: 3, ncost: 1689.2383694439168
Run: 1, iteration: 7/100, moves: 0, ncost: 1689.2383694439168
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 2, iteration: 1/100, moves: 181, ncost: 1936.4717782398006
Run: 2, iteration: 2/100, moves: 67, ncost: 1877.4028821356615
Run: 2, iteration: 3/100, moves: 36, ncost: 1857.8186735965087
Run: 2, iteration: 4/100, moves: 16, ncost: 1850.8210834807667
Run: 2, iteration: 5/100, moves: 8, ncost: 1847.4912836857611
Run: 2, iteration: 6/100, moves: 2, ncost: 1847.1870296806994
Run: 2, iteration: 7/100, moves: 0, ncost: 1847.1870296806994
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 3, iteration: 1/100, moves: 200, ncost: 1963.4329543764034
Run: 3, iteration: 2/100, moves: 105, ncost: 1846.3019861769117
Run: 3, iteration: 3/100, moves: 53, ncost: 1795.4617836815423
Run: 3, iteration: 4/100, moves: 16, ncost: 1787.4451709170005
Run: 3, iteration: 5/100, moves: 2, ncost: 1787.1485304673313
Run: 3, iteration: 6/100, moves: 0, ncost: 1787.1485304673313
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 4, iteration: 1/100, moves: 270, ncost: 1796.870864674875
Run: 4, iteration: 2/100, moves: 77, ncost: 1741.3793144032338
Run: 4, iteration: 3/100, moves: 23, ncost: 1732.2153647124862
Run: 4, iteration: 4/100, moves: 7, ncost: 1729.4014969732348
Run: 4, iteration: 5/100, moves: 1, ncost: 1729.245238691111
Run: 4, iteration: 6/100, moves: 0, ncost: 1729.245238691111
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 5, iteration: 1/100, moves: 237, ncost: 1884.7995554336076
Run: 5, iteration: 2/100, moves: 120, ncost: 1746.6342858779385
Run: 5, iteration: 3/100, moves: 43, ncost: 1727.0466195821957
Run: 5, iteration: 4/100, moves: 8, ncost: 1724.7235505434337
Run: 5, iteration: 5/100, moves: 0, ncost: 1724.7235505434337
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 238, ncost: 1903.4561430481256
Run: 6, iteration: 2/100, moves: 103, ncost: 1793.623152481352
Run: 6, iteration: 3/100, moves: 44, ncost: 1765.0918498785682
```

Run: 6, iteration: 4/100, moves: 16, ncost: 1755.7077903190352  
Run: 6, iteration: 5/100, moves: 7, ncost: 1749.905642250151  
Run: 6, iteration: 6/100, moves: 10, ncost: 1744.0122442514669  
Run: 6, iteration: 7/100, moves: 1, ncost: 1743.8703867760505  
Run: 6, iteration: 8/100, moves: 0, ncost: 1743.8703867760505  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 7, iteration: 1/100, moves: 245, ncost: 1960.609027166687  
Run: 7, iteration: 2/100, moves: 92, ncost: 1857.4118749357553  
Run: 7, iteration: 3/100, moves: 44, ncost: 1833.4006537861862  
Run: 7, iteration: 4/100, moves: 35, ncost: 1810.885973774025  
Run: 7, iteration: 5/100, moves: 20, ncost: 1801.4574953719723  
Run: 7, iteration: 6/100, moves: 21, ncost: 1793.3011880758163  
Run: 7, iteration: 7/100, moves: 9, ncost: 1790.6222628768728  
Run: 7, iteration: 8/100, moves: 9, ncost: 1784.676585236524  
Run: 7, iteration: 9/100, moves: 6, ncost: 1783.507794407093  
Run: 7, iteration: 10/100, moves: 1, ncost: 1783.2917898554008  
Run: 7, iteration: 11/100, moves: 2, ncost: 1783.023294609345  
Run: 7, iteration: 12/100, moves: 0, ncost: 1783.023294609345  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 8, iteration: 1/100, moves: 208, ncost: 1903.8424369120623  
Run: 8, iteration: 2/100, moves: 89, ncost: 1816.5152632197194  
Run: 8, iteration: 3/100, moves: 53, ncost: 1782.8292717626307  
Run: 8, iteration: 4/100, moves: 26, ncost: 1769.5595591421588  
Run: 8, iteration: 5/100, moves: 15, ncost: 1757.9725854941316  
Run: 8, iteration: 6/100, moves: 17, ncost: 1714.496541465208  
Run: 8, iteration: 7/100, moves: 12, ncost: 1702.9804615797739  
Run: 8, iteration: 8/100, moves: 4, ncost: 1701.9912579622885  
Run: 8, iteration: 9/100, moves: 0, ncost: 1701.9912579622885  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 9, iteration: 1/100, moves: 235, ncost: 1925.3463263731055  
Run: 9, iteration: 2/100, moves: 97, ncost: 1842.8606516636883  
Run: 9, iteration: 3/100, moves: 44, ncost: 1812.3002371476646  
Run: 9, iteration: 4/100, moves: 28, ncost: 1800.7700613670013  
Run: 9, iteration: 5/100, moves: 10, ncost: 1796.40999308454  
Run: 9, iteration: 6/100, moves: 4, ncost: 1795.1833554531  
Run: 9, iteration: 7/100, moves: 5, ncost: 1793.8855732282655  
Run: 9, iteration: 8/100, moves: 6, ncost: 1791.009622098586  
Run: 9, iteration: 9/100, moves: 8, ncost: 1784.912146354438  
Run: 9, iteration: 10/100, moves: 7, ncost: 1780.0014926775534  
Run: 9, iteration: 11/100, moves: 12, ncost: 1773.8914421320776  
Run: 9, iteration: 12/100, moves: 9, ncost: 1770.8313594621332  
Run: 9, iteration: 13/100, moves: 7, ncost: 1767.2084227289415  
Run: 9, iteration: 14/100, moves: 7, ncost: 1764.3421220527628  
Run: 9, iteration: 15/100, moves: 10, ncost: 1759.7899379611595  
Run: 9, iteration: 16/100, moves: 5, ncost: 1757.9548616944232  
Run: 9, iteration: 17/100, moves: 2, ncost: 1757.5425241091277  
Run: 9, iteration: 18/100, moves: 0, ncost: 1757.5425241091277  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...

```
43%|███████████| 12/28 [00:42<00:56, 3.51s/it]
```

```
Run: 10, iteration: 5/100, moves: 3, ncost: 1779.687818679421
Run: 10, iteration: 6/100, moves: 0, ncost: 1779.687818679421
Best run was number 1
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 1, iteration: 1/100, moves: 214, ncost: 1792.067080534253
Run: 1, iteration: 2/100, moves: 85, ncost: 1713.8954620088655
Run: 1, iteration: 3/100, moves: 46, ncost: 1675.8841747056088
Run: 1, iteration: 4/100, moves: 15, ncost: 1669.4757174097062
Run: 1, iteration: 5/100, moves: 8, ncost: 1667.4050015637008
Run: 1, iteration: 6/100, moves: 1, ncost: 1667.1539557703386
Run: 1, iteration: 7/100, moves: 0, ncost: 1667.1539557703386
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 2, iteration: 1/100, moves: 293, ncost: 1953.3732788575028
Run: 2, iteration: 2/100, moves: 116, ncost: 1811.1734608703914
Run: 2, iteration: 3/100, moves: 60, ncost: 1758.3622314912682
Run: 2, iteration: 4/100, moves: 22, ncost: 1747.1543374083471
Run: 2, iteration: 5/100, moves: 15, ncost: 1742.7977076787408
Run: 2, iteration: 6/100, moves: 4, ncost: 1741.938308720055
Run: 2, iteration: 7/100, moves: 3, ncost: 1741.5331999536172
Run: 2, iteration: 8/100, moves: 0, ncost: 1741.5331999536172
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 3, iteration: 1/100, moves: 212, ncost: 1760.295023687662
Run: 3, iteration: 2/100, moves: 67, ncost: 1714.6481780438355
Run: 3, iteration: 3/100, moves: 25, ncost: 1704.9318294616473
Run: 3, iteration: 4/100, moves: 22, ncost: 1691.4959902571986
Run: 3, iteration: 5/100, moves: 23, ncost: 1678.103986511085
Run: 3, iteration: 6/100, moves: 21, ncost: 1661.8940086545538
Run: 3, iteration: 7/100, moves: 18, ncost: 1654.9494563517724
Run: 3, iteration: 8/100, moves: 13, ncost: 1650.5984486361008
Run: 3, iteration: 9/100, moves: 6, ncost: 1648.843647864239
Run: 3, iteration: 10/100, moves: 0, ncost: 1648.843647864239
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 4, iteration: 1/100, moves: 225, ncost: 1765.7187498574824
Run: 4, iteration: 2/100, moves: 71, ncost: 1708.9008698949829
Run: 4, iteration: 3/100, moves: 37, ncost: 1678.933098916096
Run: 4, iteration: 4/100, moves: 27, ncost: 1659.951419441343
Run: 4, iteration: 5/100, moves: 22, ncost: 1649.072642627959
Run: 4, iteration: 6/100, moves: 6, ncost: 1647.8534851989423
Run: 4, iteration: 7/100, moves: 4, ncost: 1646.9065792396073
Run: 4, iteration: 8/100, moves: 3, ncost: 1646.2122976146964
Run: 4, iteration: 9/100, moves: 1, ncost: 1646.103865991264
Run: 4, iteration: 10/100, moves: 0, ncost: 1646.103865991264
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
```

Run: 5, iteration: 1/100, moves: 294, ncost: 1754.1539475158886  
Run: 5, iteration: 2/100, moves: 63, ncost: 1698.8661832932585  
Run: 5, iteration: 3/100, moves: 33, ncost: 1680.8953339098935  
Run: 5, iteration: 4/100, moves: 13, ncost: 1677.7916478007928  
Run: 5, iteration: 5/100, moves: 1, ncost: 1677.6529559521557  
Run: 5, iteration: 6/100, moves: 0, ncost: 1677.6529559521557  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 6, iteration: 1/100, moves: 300, ncost: 1723.2265552100798  
Run: 6, iteration: 2/100, moves: 96, ncost: 1647.765871453278  
Run: 6, iteration: 3/100, moves: 24, ncost: 1638.334374633085  
Run: 6, iteration: 4/100, moves: 19, ncost: 1631.1601396593012  
Run: 6, iteration: 5/100, moves: 13, ncost: 1626.9578556108784  
Run: 6, iteration: 6/100, moves: 3, ncost: 1626.3458754631642  
Run: 6, iteration: 7/100, moves: 3, ncost: 1625.7604925955807  
Run: 6, iteration: 8/100, moves: 2, ncost: 1625.4474191135728  
Run: 6, iteration: 9/100, moves: 0, ncost: 1625.4474191135728  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 7, iteration: 1/100, moves: 198, ncost: 1770.777501878689  
Run: 7, iteration: 2/100, moves: 92, ncost: 1687.2572608123478  
Run: 7, iteration: 3/100, moves: 27, ncost: 1676.3810920808016  
Run: 7, iteration: 4/100, moves: 9, ncost: 1672.7595784970338  
Run: 7, iteration: 5/100, moves: 5, ncost: 1671.08978886456  
Run: 7, iteration: 6/100, moves: 0, ncost: 1671.08978886456  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 8, iteration: 1/100, moves: 212, ncost: 1791.5320833122132  
Run: 8, iteration: 2/100, moves: 63, ncost: 1737.8148651654562  
Run: 8, iteration: 3/100, moves: 13, ncost: 1731.5522865115026  
Run: 8, iteration: 4/100, moves: 16, ncost: 1722.8758278099106  
Run: 8, iteration: 5/100, moves: 8, ncost: 1717.3312821024624  
Run: 8, iteration: 6/100, moves: 7, ncost: 1714.8226829592002  
Run: 8, iteration: 7/100, moves: 7, ncost: 1711.3636858726911  
Run: 8, iteration: 8/100, moves: 13, ncost: 1703.693353183641  
Run: 8, iteration: 9/100, moves: 2, ncost: 1703.464146288673  
Run: 8, iteration: 10/100, moves: 0, ncost: 1703.464146288673  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 9, iteration: 1/100, moves: 280, ncost: 1905.7796526557204  
Run: 9, iteration: 2/100, moves: 115, ncost: 1723.3778759855143  
Run: 9, iteration: 3/100, moves: 34, ncost: 1689.643156127652  
Run: 9, iteration: 4/100, moves: 9, ncost: 1686.7606967108536  
Run: 9, iteration: 5/100, moves: 2, ncost: 1685.0282780357268  
Run: 9, iteration: 6/100, moves: 3, ncost: 1683.8343125561855  
Run: 9, iteration: 7/100, moves: 0, ncost: 1683.8343125561855  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 10, iteration: 1/100, moves: 232, ncost: 1734.651314802248  
Run: 10, iteration: 2/100, moves: 78, ncost: 1679.4425036805553  
Run: 10, iteration: 3/100, moves: 26, ncost: 1665.878991087824



```
Run: 10, iteration: 4/100, moves: 16, ncost: 1657.2478432516803
Run: 10, iteration: 5/100, moves: 15, ncost: 1650.4117978693034
Run: 10, iteration: 6/100, moves: 27, ncost: 1632.2710889998
Run: 10, iteration: 7/100, moves: 9, ncost: 1628.2121656164009
Run: 10, iteration: 8/100, moves: 15, ncost: 1620.454458570705
Run: 10, iteration: 9/100, moves: 11, ncost: 1617.281990032701
Run: 10, iteration: 10/100, moves: 9, ncost: 1615.4691956401387
Run: 10, iteration: 11/100, moves: 6, ncost: 1613.8119446817882
```

46%|



| 13/28 [00:45&lt;00:51, 3.42s/it]

```
Run: 10, iteration: 12/100, moves: 5, ncost: 1612.7449095440238
Run: 10, iteration: 13/100, moves: 3, ncost: 1611.3621656849923
Run: 10, iteration: 14/100, moves: 6, ncost: 1607.8275925895307
Run: 10, iteration: 15/100, moves: 2, ncost: 1607.1577698934634
Run: 10, iteration: 16/100, moves: 0, ncost: 1607.1577698934634
Best run was number 10
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 1, iteration: 1/100, moves: 192, ncost: 1771.6853551926013
Run: 1, iteration: 2/100, moves: 54, ncost: 1730.1925419359306
Run: 1, iteration: 3/100, moves: 41, ncost: 1703.3316691475704
Run: 1, iteration: 4/100, moves: 23, ncost: 1691.3120725220385
Run: 1, iteration: 5/100, moves: 14, ncost: 1684.69577478263
Run: 1, iteration: 6/100, moves: 10, ncost: 1680.2517681705988
Run: 1, iteration: 7/100, moves: 8, ncost: 1677.2973259598816
Run: 1, iteration: 8/100, moves: 3, ncost: 1676.6108845482574
Run: 1, iteration: 9/100, moves: 5, ncost: 1675.2681604732866
Run: 1, iteration: 10/100, moves: 3, ncost: 1674.7232599093145
Run: 1, iteration: 11/100, moves: 1, ncost: 1674.5199414512463
Run: 1, iteration: 12/100, moves: 0, ncost: 1674.5199414512463
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 2, iteration: 1/100, moves: 229, ncost: 1811.9445656154344
Run: 2, iteration: 2/100, moves: 81, ncost: 1699.8910136859695
Run: 2, iteration: 3/100, moves: 38, ncost: 1655.385920720129
Run: 2, iteration: 4/100, moves: 29, ncost: 1639.0328441026636
Run: 2, iteration: 5/100, moves: 10, ncost: 1636.9368202734652
Run: 2, iteration: 6/100, moves: 4, ncost: 1634.6286006768516
Run: 2, iteration: 7/100, moves: 7, ncost: 1631.6644883378606
Run: 2, iteration: 8/100, moves: 3, ncost: 1631.0481694509285
Run: 2, iteration: 9/100, moves: 1, ncost: 1630.9620686808403
Run: 2, iteration: 10/100, moves: 0, ncost: 1630.9620686808403
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 3, iteration: 1/100, moves: 256, ncost: 1815.9863688841656
Run: 3, iteration: 2/100, moves: 78, ncost: 1691.980875589596
Run: 3, iteration: 3/100, moves: 30, ncost: 1659.2137321378348
Run: 3, iteration: 4/100, moves: 24, ncost: 1643.5339983161089
Run: 3, iteration: 5/100, moves: 10, ncost: 1638.7521993618311
Run: 3, iteration: 6/100, moves: 4, ncost: 1637.7364135378587
Run: 3, iteration: 7/100, moves: 0, ncost: 1637.7364135378587
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 4, iteration: 1/100, moves: 223, ncost: 1776.1026195551344
Run: 4, iteration: 2/100, moves: 71, ncost: 1699.445881014744
```

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Run: 4, iteration: 3/100, moves: 41, ncost: 1675.8516078134835
Run: 4, iteration: 4/100, moves: 12, ncost: 1670.521900376117
Run: 4, iteration: 5/100, moves: 9, ncost: 1662.9071902251405
Run: 4, iteration: 6/100, moves: 2, ncost: 1662.058663747626
Run: 4, iteration: 7/100, moves: 1, ncost: 1661.8487575584452
Run: 4, iteration: 8/100, moves: 1, ncost: 1661.7294868187296
Run: 4, iteration: 9/100, moves: 0, ncost: 1661.7294868187296
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 5, iteration: 1/100, moves: 269, ncost: 1718.1489620017592
Run: 5, iteration: 2/100, moves: 97, ncost: 1627.1440472077668
Run: 5, iteration: 3/100, moves: 28, ncost: 1609.0198890968377
Run: 5, iteration: 4/100, moves: 13, ncost: 1604.4881995012863
Run: 5, iteration: 5/100, moves: 2, ncost: 1604.0653681911995
Run: 5, iteration: 6/100, moves: 0, ncost: 1604.0653681911995
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 207, ncost: 1770.9601316611104
Run: 6, iteration: 2/100, moves: 75, ncost: 1685.2231742530203
Run: 6, iteration: 3/100, moves: 33, ncost: 1670.5444690675104
Run: 6, iteration: 4/100, moves: 11, ncost: 1665.9862070580282
Run: 6, iteration: 5/100, moves: 3, ncost: 1664.965801336693
Run: 6, iteration: 6/100, moves: 4, ncost: 1663.6112457538143
Run: 6, iteration: 7/100, moves: 3, ncost: 1662.9918189863488
Run: 6, iteration: 8/100, moves: 0, ncost: 1662.9918189863488
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 249, ncost: 1703.5467328894356
Run: 7, iteration: 2/100, moves: 79, ncost: 1651.226356833275
Run: 7, iteration: 3/100, moves: 16, ncost: 1642.7562095239318
Run: 7, iteration: 4/100, moves: 19, ncost: 1625.3797750944486
Run: 7, iteration: 5/100, moves: 23, ncost: 1603.7686878189706
Run: 7, iteration: 6/100, moves: 18, ncost: 1584.9576465085088
Run: 7, iteration: 7/100, moves: 7, ncost: 1581.4924258645167
Run: 7, iteration: 8/100, moves: 8, ncost: 1578.3077723265662
Run: 7, iteration: 9/100, moves: 8, ncost: 1575.9612058590262
Run: 7, iteration: 10/100, moves: 8, ncost: 1573.5643877863577
Run: 7, iteration: 11/100, moves: 2, ncost: 1573.3137749840023
Run: 7, iteration: 12/100, moves: 0, ncost: 1573.3137749840023
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 297, ncost: 1829.5830113107231
Run: 8, iteration: 2/100, moves: 99, ncost: 1745.035608310252
Run: 8, iteration: 3/100, moves: 44, ncost: 1724.258372777118
Run: 8, iteration: 4/100, moves: 26, ncost: 1699.1286178685655
Run: 8, iteration: 5/100, moves: 27, ncost: 1676.0939567739074
Run: 8, iteration: 6/100, moves: 20, ncost: 1667.0686828060404
Run: 8, iteration: 7/100, moves: 5, ncost: 1666.1179070695428
Run: 8, iteration: 8/100, moves: 7, ncost: 1662.474416816354
Run: 8, iteration: 9/100, moves: 2, ncost: 1661.9746519416408
```

[illegible]

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Run: 10, iteration: 3/100, moves: 66, ncost: 1614.4330171299698
Run: 10, iteration: 4/100, moves: 23, ncost: 1605.9653739788782
Run: 10, iteration: 5/100, moves: 21, ncost: 1597.9550817386607
Run: 10, iteration: 6/100, moves: 2, ncost: 1597.725863429754
Run: 10, iteration: 7/100, moves: 0, ncost: 1597.725863429754
Best run was number 7
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 1, iteration: 1/100, moves: 179, ncost: 1680.9848868836705
Run: 1, iteration: 2/100, moves: 78, ncost: 1602.89843543491
Run: 1, iteration: 3/100, moves: 44, ncost: 1578.872852842594
Run: 1, iteration: 4/100, moves: 14, ncost: 1573.682342088004
Run: 1, iteration: 5/100, moves: 14, ncost: 1568.0843562642542
Run: 1, iteration: 6/100, moves: 7, ncost: 1566.1848845288898
Run: 1, iteration: 7/100, moves: 9, ncost: 1563.8604691343685
Run: 1, iteration: 8/100, moves: 10, ncost: 1561.2770013550605
Run: 1, iteration: 9/100, moves: 3, ncost: 1560.4800914930938
Run: 1, iteration: 10/100, moves: 8, ncost: 1558.8852063111033
Run: 1, iteration: 11/100, moves: 2, ncost: 1558.6236288694452
Run: 1, iteration: 12/100, moves: 0, ncost: 1558.6236288694452
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 2, iteration: 1/100, moves: 240, ncost: 1770.7525950595862
Run: 2, iteration: 2/100, moves: 100, ncost: 1663.031852826702
Run: 2, iteration: 3/100, moves: 40, ncost: 1640.6449212102157
Run: 2, iteration: 4/100, moves: 24, ncost: 1627.5176820540867
Run: 2, iteration: 5/100, moves: 7, ncost: 1624.617428320054
Run: 2, iteration: 6/100, moves: 0, ncost: 1624.617428320054
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 3, iteration: 1/100, moves: 191, ncost: 1829.5739535080693
Run: 3, iteration: 2/100, moves: 94, ncost: 1707.3698185390392
Run: 3, iteration: 3/100, moves: 26, ncost: 1694.0119692006208
Run: 3, iteration: 4/100, moves: 10, ncost: 1690.5688770324703
Run: 3, iteration: 5/100, moves: 3, ncost: 1689.6265295606217
Run: 3, iteration: 6/100, moves: 0, ncost: 1689.6265295606217
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 4, iteration: 1/100, moves: 267, ncost: 1718.0585129167353
Run: 4, iteration: 2/100, moves: 81, ncost: 1619.929876976612
Run: 4, iteration: 3/100, moves: 50, ncost: 1582.6039074681482
Run: 4, iteration: 4/100, moves: 28, ncost: 1567.6539166885514
Run: 4, iteration: 5/100, moves: 11, ncost: 1562.1919827519332
Run: 4, iteration: 6/100, moves: 3, ncost: 1561.6387215176844
Run: 4, iteration: 7/100, moves: 0, ncost: 1561.6387215176844
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 5, iteration: 1/100, moves: 262, ncost: 1709.7045934374953
Run: 5, iteration: 2/100, moves: 81, ncost: 1615.6013115214284
Run: 5, iteration: 3/100, moves: 46, ncost: 1575.9732644138346
Run: 5, iteration: 4/100, moves: 23, ncost: 1566.5891719627764
Run: 5, iteration: 5/100, moves: 17, ncost: 1557.3156441312146
```

```
Run: 5, iteration: 6/100, moves: 16, ncost: 1546.2895733690982
Run: 5, iteration: 7/100, moves: 6, ncost: 1542.9509537311465
Run: 5, iteration: 8/100, moves: 4, ncost: 1541.8762521915553
Run: 5, iteration: 9/100, moves: 0, ncost: 1541.8762521915553
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 259, ncost: 1834.9433969409636
Run: 6, iteration: 2/100, moves: 97, ncost: 1724.4515979025634
Run: 6, iteration: 3/100, moves: 51, ncost: 1674.7452947761712
Run: 6, iteration: 4/100, moves: 28, ncost: 1632.2024130046752
Run: 6, iteration: 5/100, moves: 15, ncost: 1625.1765771502216
Run: 6, iteration: 6/100, moves: 16, ncost: 1617.7212950660598
Run: 6, iteration: 7/100, moves: 8, ncost: 1615.7338679182633
Run: 6, iteration: 8/100, moves: 4, ncost: 1614.6710658561342
Run: 6, iteration: 9/100, moves: 1, ncost: 1614.5628200017502
Run: 6, iteration: 10/100, moves: 0, ncost: 1614.5628200017502
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 249, ncost: 1656.4920170874072
Run: 7, iteration: 2/100, moves: 59, ncost: 1616.9761313141332
Run: 7, iteration: 3/100, moves: 27, ncost: 1602.0531058221743
Run: 7, iteration: 4/100, moves: 21, ncost: 1591.5302522427664
Run: 7, iteration: 5/100, moves: 14, ncost: 1586.2134525420033
Run: 7, iteration: 6/100, moves: 9, ncost: 1584.1070183876755
Run: 7, iteration: 7/100, moves: 5, ncost: 1581.2516652464042
Run: 7, iteration: 8/100, moves: 2, ncost: 1580.6566942856239
Run: 7, iteration: 9/100, moves: 4, ncost: 1579.6557050932379
Run: 7, iteration: 10/100, moves: 0, ncost: 1579.6557050932379
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 248, ncost: 1744.8093139133123
Run: 8, iteration: 2/100, moves: 87, ncost: 1659.98386589929
Run: 8, iteration: 3/100, moves: 25, ncost: 1646.6439969709954
Run: 8, iteration: 4/100, moves: 11, ncost: 1641.9573859516418
Run: 8, iteration: 5/100, moves: 19, ncost: 1629.4396108611643
Run: 8, iteration: 6/100, moves: 7, ncost: 1625.8456145882778
Run: 8, iteration: 7/100, moves: 2, ncost: 1625.4716276629308
Run: 8, iteration: 8/100, moves: 0, ncost: 1625.4716276629308
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 207, ncost: 1780.5280007078388
Run: 9, iteration: 2/100, moves: 61, ncost: 1723.9127623178592
Run: 9, iteration: 3/100, moves: 51, ncost: 1657.4568028307062
Run: 9, iteration: 4/100, moves: 43, ncost: 1625.770951019335
Run: 9, iteration: 5/100, moves: 33, ncost: 1603.3658740185504
Run: 9, iteration: 6/100, moves: 19, ncost: 1596.9192359248882
Run: 9, iteration: 7/100, moves: 14, ncost: 1592.084347088612
Run: 9, iteration: 8/100, moves: 9, ncost: 1588.7822194416588
```

```
Run: 9, iteration: 9/100, moves: 5, ncost: 1587.525958965036  
Run: 9, iteration: 10/100, moves: 2, ncost: 1587.210619232208  
Run: 9, iteration: 11/100, moves: 3, ncost: 1586.6192839216542  
Run: 9, iteration: 12/100, moves: 0, ncost: 1586.6192839216542  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 10, iteration: 1/100, moves: 241, ncost: 1681.1571037071233
```

54%

| 15/28 [00:51<00:41, 3.20s/it]

```
Run: 10, iteration: 2/100, moves: 100, ncost: 1602.8617626593239
Run: 10, iteration: 3/100, moves: 34, ncost: 1578.013312551054
Run: 10, iteration: 4/100, moves: 25, ncost: 1557.578025989121
Run: 10, iteration: 5/100, moves: 8, ncost: 1555.3258409634484
Run: 10, iteration: 6/100, moves: 0, ncost: 1555.3258409634484
Best run was number 5
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 1, iteration: 1/100, moves: 264, ncost: 1654.2276935238676
Run: 1, iteration: 2/100, moves: 82, ncost: 1587.0008295008124
Run: 1, iteration: 3/100, moves: 33, ncost: 1565.9718337193553
Run: 1, iteration: 4/100, moves: 28, ncost: 1542.9377944516302
Run: 1, iteration: 5/100, moves: 22, ncost: 1531.0458973906827
Run: 1, iteration: 6/100, moves: 8, ncost: 1528.9506232665199
Run: 1, iteration: 7/100, moves: 6, ncost: 1527.3782513036283
Run: 1, iteration: 8/100, moves: 2, ncost: 1526.9022634467835
Run: 1, iteration: 9/100, moves: 1, ncost: 1526.7708722159907
Run: 1, iteration: 10/100, moves: 0, ncost: 1526.7708722159907
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 2, iteration: 1/100, moves: 228, ncost: 1668.5418083845493
Run: 2, iteration: 2/100, moves: 81, ncost: 1607.683717216177
Run: 2, iteration: 3/100, moves: 20, ncost: 1597.3730905692803
Run: 2, iteration: 4/100, moves: 7, ncost: 1594.3199322556604
Run: 2, iteration: 5/100, moves: 6, ncost: 1587.9125363043959
Run: 2, iteration: 6/100, moves: 17, ncost: 1557.655889487831
Run: 2, iteration: 7/100, moves: 22, ncost: 1539.6877855797325
Run: 2, iteration: 8/100, moves: 9, ncost: 1534.5983483929376
Run: 2, iteration: 9/100, moves: 10, ncost: 1530.8455276204484
Run: 2, iteration: 10/100, moves: 6, ncost: 1528.7261414641512
Run: 2, iteration: 11/100, moves: 2, ncost: 1527.944429917138
Run: 2, iteration: 12/100, moves: 0, ncost: 1527.944429917138
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 3, iteration: 1/100, moves: 245, ncost: 1635.5968422871256
Run: 3, iteration: 2/100, moves: 85, ncost: 1570.0196776111552
Run: 3, iteration: 3/100, moves: 39, ncost: 1546.3296994659743
Run: 3, iteration: 4/100, moves: 13, ncost: 1538.2855778511832
Run: 3, iteration: 5/100, moves: 12, ncost: 1533.2189960571993
Run: 3, iteration: 6/100, moves: 3, ncost: 1532.5852087687463
Run: 3, iteration: 7/100, moves: 1, ncost: 1532.506320835047
Run: 3, iteration: 8/100, moves: 0, ncost: 1532.506320835047
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 4, iteration: 1/100, moves: 249, ncost: 1692.5827590112926
Run: 4, iteration: 2/100, moves: 94, ncost: 1582.5998084620085
Run: 4, iteration: 3/100, moves: 53, ncost: 1549.3957995641388
```



```
Run: 4, iteration: 4/100, moves: 13, ncost: 1545.0764366878273
Run: 4, iteration: 5/100, moves: 9, ncost: 1543.042001871454
Run: 4, iteration: 6/100, moves: 3, ncost: 1541.9893683625423
Run: 4, iteration: 7/100, moves: 2, ncost: 1541.714855766547
Run: 4, iteration: 8/100, moves: 1, ncost: 1541.51462519204
Run: 4, iteration: 9/100, moves: 4, ncost: 1540.4225050331104
Run: 4, iteration: 10/100, moves: 2, ncost: 1540.1246337396085
Run: 4, iteration: 11/100, moves: 0, ncost: 1540.1246337396085
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 5, iteration: 1/100, moves: 210, ncost: 1693.634194180104
Run: 5, iteration: 2/100, moves: 85, ncost: 1620.8985512475606
Run: 5, iteration: 3/100, moves: 45, ncost: 1593.2316047972492
Run: 5, iteration: 4/100, moves: 8, ncost: 1589.013846000529
Run: 5, iteration: 5/100, moves: 12, ncost: 1581.7071760316069
Run: 5, iteration: 6/100, moves: 9, ncost: 1578.9816179999173
Run: 5, iteration: 7/100, moves: 8, ncost: 1575.7637329978033
Run: 5, iteration: 8/100, moves: 7, ncost: 1573.624834834214
Run: 5, iteration: 9/100, moves: 2, ncost: 1573.5086190981383
Run: 5, iteration: 10/100, moves: 0, ncost: 1573.5086190981383
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 210, ncost: 1676.241413215664
Run: 6, iteration: 2/100, moves: 87, ncost: 1590.7712179303921
Run: 6, iteration: 3/100, moves: 27, ncost: 1565.8352645539267
Run: 6, iteration: 4/100, moves: 14, ncost: 1553.6858925477313
Run: 6, iteration: 5/100, moves: 13, ncost: 1545.8646945079552
Run: 6, iteration: 6/100, moves: 14, ncost: 1537.3144491884009
Run: 6, iteration: 7/100, moves: 6, ncost: 1536.2240910668625
Run: 6, iteration: 8/100, moves: 5, ncost: 1530.9797543203504
Run: 6, iteration: 9/100, moves: 11, ncost: 1524.3671354281648
Run: 6, iteration: 10/100, moves: 2, ncost: 1523.2174649909566
Run: 6, iteration: 11/100, moves: 3, ncost: 1521.7721524780895
Run: 6, iteration: 12/100, moves: 1, ncost: 1521.1324808389231
Run: 6, iteration: 13/100, moves: 0, ncost: 1521.1324808389231
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 218, ncost: 1687.6224499621921
Run: 7, iteration: 2/100, moves: 72, ncost: 1630.259854778538
Run: 7, iteration: 3/100, moves: 19, ncost: 1623.7064717137655
Run: 7, iteration: 4/100, moves: 9, ncost: 1620.222456981194
Run: 7, iteration: 5/100, moves: 5, ncost: 1618.788105463207
Run: 7, iteration: 6/100, moves: 2, ncost: 1618.3194919174775
Run: 7, iteration: 7/100, moves: 0, ncost: 1618.3194919174775
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 219, ncost: 1648.562702362206
Run: 8, iteration: 2/100, moves: 72, ncost: 1591.9565592279346
Run: 8, iteration: 3/100, moves: 36, ncost: 1571.5457341364136
Run: 8, iteration: 4/100, moves: 28, ncost: 1555.7965603871728
```

```
Run: 8, iteration: 5/100, moves: 27, ncost: 1543.644166894263
Run: 8, iteration: 6/100, moves: 8, ncost: 1540.4550377178846
Run: 8, iteration: 7/100, moves: 6, ncost: 1537.1127063548872
Run: 8, iteration: 8/100, moves: 7, ncost: 1534.0035386357208
Run: 8, iteration: 9/100, moves: 1, ncost: 1533.8170336543837
Run: 8, iteration: 10/100, moves: 1, ncost: 1533.702917323606
Run: 8, iteration: 11/100, moves: 0, ncost: 1533.702917323606
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 238, ncost: 1612.3124044684173
Run: 9, iteration: 2/100, moves: 86, ncost: 1555.0005871206183
Run: 9, iteration: 3/100, moves: 34, ncost: 1524.9021659102013
Run: 9, iteration: 4/100, moves: 21, ncost: 1513.441104900822
Run: 9, iteration: 5/100, moves: 11, ncost: 1509.278477171843
Run: 9, iteration: 6/100, moves: 10, ncost: 1500.4358427701936
Run: 9, iteration: 7/100, moves: 1, ncost: 1500.1479929622353
Run: 9, iteration: 8/100, moves: 0, ncost: 1500.1479929622353
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 10, iteration: 1/100, moves: 216, ncost: 1735.7604472665737
Run: 10, iteration: 2/100, moves: 66, ncost: 1670.7300963707526
Run: 10, iteration: 3/100, moves: 39, ncost: 1639.9974439962302
Run: 10, iteration: 4/100, moves: 13, ncost: 1635.0638040763104
Run: 10, iteration: 5/100, moves: 5, ncost: 1633.3033309493703
```

57%

| 16/28 [00:55<00:40, 3.34s/it]

```
Run: 10, iteration: 6/100, moves: 3, ncost: 1622.916509154618
Run: 10, iteration: 7/100, moves: 5, ncost: 1619.9178156994187
Run: 10, iteration: 8/100, moves: 7, ncost: 1616.7983922647923
Run: 10, iteration: 9/100, moves: 5, ncost: 1615.5465958251662
Run: 10, iteration: 10/100, moves: 1, ncost: 1615.4202046073942
Run: 10, iteration: 11/100, moves: 0, ncost: 1615.4202046073942
Best run was number 9
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 1, iteration: 1/100, moves: 228, ncost: 1664.8180605097432
Run: 1, iteration: 2/100, moves: 78, ncost: 1580.0705192904616
Run: 1, iteration: 3/100, moves: 55, ncost: 1525.5507041026522
Run: 1, iteration: 4/100, moves: 23, ncost: 1508.2021307894643
Run: 1, iteration: 5/100, moves: 9, ncost: 1503.922346296628
Run: 1, iteration: 6/100, moves: 13, ncost: 1493.662352853989
Run: 1, iteration: 7/100, moves: 13, ncost: 1480.3188779565567
Run: 1, iteration: 8/100, moves: 7, ncost: 1476.86656571298
Run: 1, iteration: 9/100, moves: 4, ncost: 1476.141720552734
Run: 1, iteration: 10/100, moves: 2, ncost: 1475.7769750957546
Run: 1, iteration: 11/100, moves: 0, ncost: 1475.7769750957546
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 2, iteration: 1/100, moves: 187, ncost: 1687.0093210909606
Run: 2, iteration: 2/100, moves: 70, ncost: 1596.3162519221926
Run: 2, iteration: 3/100, moves: 60, ncost: 1538.2666339014074
Run: 2, iteration: 4/100, moves: 32, ncost: 1515.5606834343696
Run: 2, iteration: 5/100, moves: 29, ncost: 1498.4261085713615
Run: 2, iteration: 6/100, moves: 13, ncost: 1492.8924385624928
Run: 2, iteration: 7/100, moves: 9, ncost: 1488.0467984985066
Run: 2, iteration: 8/100, moves: 11, ncost: 1476.9601940127395
Run: 2, iteration: 9/100, moves: 8, ncost: 1469.882245117836
Run: 2, iteration: 10/100, moves: 10, ncost: 1466.1786525754094
Run: 2, iteration: 11/100, moves: 14, ncost: 1459.4538313840983
Run: 2, iteration: 12/100, moves: 8, ncost: 1457.2199341391834
Run: 2, iteration: 13/100, moves: 4, ncost: 1455.2118441491
Run: 2, iteration: 14/100, moves: 6, ncost: 1452.8222131278371
Run: 2, iteration: 15/100, moves: 3, ncost: 1451.5784218497943
Run: 2, iteration: 16/100, moves: 3, ncost: 1450.5877560428596
Run: 2, iteration: 17/100, moves: 5, ncost: 1448.4822427954805
Run: 2, iteration: 18/100, moves: 7, ncost: 1445.7227220613606
Run: 2, iteration: 19/100, moves: 4, ncost: 1445.3394986392677
Run: 2, iteration: 20/100, moves: 0, ncost: 1445.3394986392677
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
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Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 3, iteration: 1/100, moves: 262, ncost: 1622.8321284002143
Run: 3, iteration: 2/100, moves: 95, ncost: 1518.6755718568947
Run: 3, iteration: 3/100, moves: 44, ncost: 1475.8864158742401
Run: 3, iteration: 4/100, moves: 23, ncost: 1466.9265083109617
Run: 3, iteration: 5/100, moves: 14, ncost: 1460.8016094015102
Run: 3, iteration: 6/100, moves: 10, ncost: 1457.613126223683
```

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Run: 3, iteration: 7/100, moves: 5, ncost: 1455.8997477728246
Run: 3, iteration: 8/100, moves: 1, ncost: 1455.7751458637
Run: 3, iteration: 9/100, moves: 0, ncost: 1455.7751458637
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 4, iteration: 1/100, moves: 217, ncost: 1605.0429412451026
Run: 4, iteration: 2/100, moves: 74, ncost: 1567.1264737774445
Run: 4, iteration: 3/100, moves: 18, ncost: 1555.9200362970762
Run: 4, iteration: 4/100, moves: 21, ncost: 1540.4218522452175
Run: 4, iteration: 5/100, moves: 8, ncost: 1535.7327124572848
Run: 4, iteration: 6/100, moves: 1, ncost: 1535.661688136338
Run: 4, iteration: 7/100, moves: 0, ncost: 1535.661688136338
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 5, iteration: 1/100, moves: 270, ncost: 1624.1101910085304
Run: 5, iteration: 2/100, moves: 74, ncost: 1536.0537574286618
Run: 5, iteration: 3/100, moves: 27, ncost: 1518.133373198523
Run: 5, iteration: 4/100, moves: 10, ncost: 1513.0874826195964
Run: 5, iteration: 5/100, moves: 8, ncost: 1510.4537526320898
Run: 5, iteration: 6/100, moves: 3, ncost: 1509.8484463313898
Run: 5, iteration: 7/100, moves: 1, ncost: 1509.6866668120633
Run: 5, iteration: 8/100, moves: 0, ncost: 1509.6866668120633
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 187, ncost: 1675.9813614893674
Run: 6, iteration: 2/100, moves: 54, ncost: 1620.6910070936563
Run: 6, iteration: 3/100, moves: 27, ncost: 1609.2616708375124
Run: 6, iteration: 4/100, moves: 9, ncost: 1605.7630550674517
Run: 6, iteration: 5/100, moves: 7, ncost: 1603.7239042155609
Run: 6, iteration: 6/100, moves: 15, ncost: 1593.7878537259455
Run: 6, iteration: 7/100, moves: 13, ncost: 1588.8394579600315
Run: 6, iteration: 8/100, moves: 11, ncost: 1585.630370863009
Run: 6, iteration: 9/100, moves: 4, ncost: 1584.3673091753947
Run: 6, iteration: 10/100, moves: 2, ncost: 1583.9629832594187
Run: 6, iteration: 11/100, moves: 5, ncost: 1583.153248760288
Run: 6, iteration: 12/100, moves: 2, ncost: 1582.9797332248152
Run: 6, iteration: 13/100, moves: 0, ncost: 1582.9797332248152
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 310, ncost: 1687.8061339563055
Run: 7, iteration: 2/100, moves: 120, ncost: 1544.0862080076254
Run: 7, iteration: 3/100, moves: 48, ncost: 1511.1612475404302
Run: 7, iteration: 4/100, moves: 32, ncost: 1495.6622223294587
Run: 7, iteration: 5/100, moves: 15, ncost: 1490.0546141538075
Run: 7, iteration: 6/100, moves: 11, ncost: 1486.5391224775126
Run: 7, iteration: 7/100, moves: 4, ncost: 1484.6676618867452
Run: 7, iteration: 8/100, moves: 0, ncost: 1484.6676618867452
Init: initializing centroids
Init: initializing clusters
Starting iterations...
```

[illegible]

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Run: 10, iteration: 6/100, moves: 28, ncost: 1452.1316409180574
Run: 10, iteration: 7/100, moves: 18, ncost: 1439.2951114065336
Run: 10, iteration: 8/100, moves: 4, ncost: 1438.6848049776645
Run: 10, iteration: 9/100, moves: 3, ncost: 1437.2333514701054
Run: 10, iteration: 10/100, moves: 1, ncost: 1437.0081201764133
Run: 10, iteration: 11/100, moves: 0, ncost: 1437.0081201764133
Best run was number 10
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
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Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 1, iteration: 1/100, moves: 299, ncost: 1646.0379076008965
Run: 1, iteration: 2/100, moves: 93, ncost: 1541.0935730619326
Run: 1, iteration: 3/100, moves: 70, ncost: 1480.055879090732
Run: 1, iteration: 4/100, moves: 29, ncost: 1451.7936145611905
Run: 1, iteration: 5/100, moves: 18, ncost: 1440.467570857027
Run: 1, iteration: 6/100, moves: 11, ncost: 1435.8628193401091
Run: 1, iteration: 7/100, moves: 4, ncost: 1434.9167976066988
Run: 1, iteration: 8/100, moves: 1, ncost: 1434.7875030973876
Run: 1, iteration: 9/100, moves: 0, ncost: 1434.7875030973876
Init: initializing centroids
Init: initializing clusters
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Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 2, iteration: 1/100, moves: 294, ncost: 1591.2791748958548
Run: 2, iteration: 2/100, moves: 100, ncost: 1498.433477963601
Run: 2, iteration: 3/100, moves: 44, ncost: 1474.0529446548285
Run: 2, iteration: 4/100, moves: 30, ncost: 1455.4999800267765
Run: 2, iteration: 5/100, moves: 24, ncost: 1441.4029399240626
Run: 2, iteration: 6/100, moves: 14, ncost: 1436.3993366654183
Run: 2, iteration: 7/100, moves: 5, ncost: 1434.0169437929471
Run: 2, iteration: 8/100, moves: 1, ncost: 1433.76819671434
Run: 2, iteration: 9/100, moves: 0, ncost: 1433.76819671434
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
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Init: initializing centroids
Init: initializing clusters
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Starting iterations...  
Run: 3, iteration: 1/100, moves: 248, ncost: 1629.090291376614  
Run: 3, iteration: 2/100, moves: 95, ncost: 1509.762172403793  
Run: 3, iteration: 3/100, moves: 38, ncost: 1487.2447712042099  
Run: 3, iteration: 4/100, moves: 16, ncost: 1480.0489210321357  
Run: 3, iteration: 5/100, moves: 18, ncost: 1465.2500940006976  
Run: 3, iteration: 6/100, moves: 15, ncost: 1458.6361921283903  
Run: 3, iteration: 7/100, moves: 1, ncost: 1458.531750452521  
Run: 3, iteration: 8/100, moves: 0, ncost: 1458.531750452521  
Init: initializing centroids  
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Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 4, iteration: 1/100, moves: 239, ncost: 1534.5250284056046  
Run: 4, iteration: 2/100, moves: 49, ncost: 1507.7065184942528  
Run: 4, iteration: 3/100, moves: 10, ncost: 1503.7068158370057  
Run: 4, iteration: 4/100, moves: 15, ncost: 1497.7242037710037  
Run: 4, iteration: 5/100, moves: 5, ncost: 1494.9951940805158  
Run: 4, iteration: 6/100, moves: 5, ncost: 1492.4442965064147  
Run: 4, iteration: 7/100, moves: 10, ncost: 1488.7502261637876  
Run: 4, iteration: 8/100, moves: 3, ncost: 1488.1741494852029  
Run: 4, iteration: 9/100, moves: 5, ncost: 1486.178269118779  
Run: 4, iteration: 10/100, moves: 1, ncost: 1486.0933511768326
```

[illegible]



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| 64%|███████████████████████████████████████|
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| 18/28 [01:02<00:35, 3.58s/it]
```

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Run: 10, iteration: 2/100, moves: 96, ncost: 1438.8036439480786  
Run: 10, iteration: 3/100, moves: 24, ncost: 1425.33615684795  
Run: 10, iteration: 4/100, moves: 15, ncost: 1417.3273609659113  
Run: 10, iteration: 5/100, moves: 5, ncost: 1416.3326936173012  
Run: 10, iteration: 6/100, moves: 1, ncost: 1415.9748246781535  
Run: 10, iteration: 7/100, moves: 0, ncost: 1415.9748246781535  
Best run was number 8  
Initialization method and algorithm are deterministic. Setting n_init to 1.  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 1, iteration: 1/100, moves: 261, ncost: 1523.087280307396  
Run: 1, iteration: 2/100, moves: 75, ncost: 1471.66980963255  
Run: 1, iteration: 3/100, moves: 29, ncost: 1458.7007921162947  
Run: 1, iteration: 4/100, moves: 17, ncost: 1453.3033255705623  
Run: 1, iteration: 5/100, moves: 9, ncost: 1450.7303311351768  
Run: 1, iteration: 6/100, moves: 2, ncost: 1450.385205449762  
Run: 1, iteration: 7/100, moves: 4, ncost: 1449.7325531131285  
Run: 1, iteration: 8/100, moves: 8, ncost: 1447.4188518659678  
Run: 1, iteration: 9/100, moves: 6, ncost: 1445.5491560549362  
Run: 1, iteration: 10/100, moves: 1, ncost: 1445.4833686808029  
Run: 1, iteration: 11/100, moves: 0, ncost: 1445.4833686808029  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 2, iteration: 1/100, moves: 214, ncost: 1523.8682266601247  
Run: 2, iteration: 2/100, moves: 75, ncost: 1460.0679977483765  
Run: 2, iteration: 3/100, moves: 30, ncost: 1442.327590645651  
Run: 2, iteration: 4/100, moves: 13, ncost: 1436.7545148772938  
Run: 2, iteration: 5/100, moves: 11, ncost: 1431.943990919876  
Run: 2, iteration: 6/100, moves: 3, ncost: 1431.480875622646  
Run: 2, iteration: 7/100, moves: 0, ncost: 1431.480875622646  
Init: initializing centroids  
Init: initializing clusters  
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Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 3, iteration: 1/100, moves: 233, ncost: 1530.5234172327066  
Run: 3, iteration: 2/100, moves: 45, ncost: 1496.9576990267246  
Run: 3, iteration: 3/100, moves: 32, ncost: 1472.9605728088304  
Run: 3, iteration: 4/100, moves: 19, ncost: 1461.7465262418452  
Run: 3, iteration: 5/100, moves: 14, ncost: 1457.0121517134548  
Run: 3, iteration: 6/100, moves: 3, ncost: 1455.817193097556  
Run: 3, iteration: 7/100, moves: 2, ncost: 1455.4808938336525  
Run: 3, iteration: 8/100, moves: 0, ncost: 1455.4808938336525  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids
```

```
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 4, iteration: 1/100, moves: 243, ncost: 1583.2649377999462
Run: 4, iteration: 2/100, moves: 69, ncost: 1513.8003350479348
Run: 4, iteration: 3/100, moves: 57, ncost: 1466.8496735181084
Run: 4, iteration: 4/100, moves: 32, ncost: 1446.7396768600208
Run: 4, iteration: 5/100, moves: 17, ncost: 1433.3850562841524
Run: 4, iteration: 6/100, moves: 14, ncost: 1425.6559816875827
Run: 4, iteration: 7/100, moves: 4, ncost: 1424.234602647751
Run: 4, iteration: 8/100, moves: 0, ncost: 1424.234602647751
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 5, iteration: 1/100, moves: 244, ncost: 1592.4520640276432
Run: 5, iteration: 2/100, moves: 66, ncost: 1542.315336303866
Run: 5, iteration: 3/100, moves: 43, ncost: 1508.87584023033
Run: 5, iteration: 4/100, moves: 33, ncost: 1485.5290747666534
Run: 5, iteration: 5/100, moves: 30, ncost: 1464.1064982578564
Run: 5, iteration: 6/100, moves: 15, ncost: 1456.2616895838364
Run: 5, iteration: 7/100, moves: 2, ncost: 1455.4177746697458
Run: 5, iteration: 8/100, moves: 6, ncost: 1452.6124724428282
Run: 5, iteration: 9/100, moves: 9, ncost: 1448.3740687487648
Run: 5, iteration: 10/100, moves: 6, ncost: 1446.2677024820052
Run: 5, iteration: 11/100, moves: 4, ncost: 1444.8528004227855
Run: 5, iteration: 12/100, moves: 2, ncost: 1444.2665287091302
Run: 5, iteration: 13/100, moves: 1, ncost: 1444.1219134770547
Run: 5, iteration: 14/100, moves: 0, ncost: 1444.1219134770547
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
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Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 154, ncost: 1571.3276180993748
Run: 6, iteration: 2/100, moves: 66, ncost: 1486.3676171522156
Run: 6, iteration: 3/100, moves: 50, ncost: 1443.1788134427272
Run: 6, iteration: 4/100, moves: 29, ncost: 1421.5552776198147
Run: 6, iteration: 5/100, moves: 18, ncost: 1412.6898842643843
Run: 6, iteration: 6/100, moves: 9, ncost: 1408.2612745114805
Run: 6, iteration: 7/100, moves: 3, ncost: 1407.2483235755124
Run: 6, iteration: 8/100, moves: 1, ncost: 1407.1411245998656
Run: 6, iteration: 9/100, moves: 0, ncost: 1407.1411245998656
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
```

Run: 7, iteration: 1/100, moves: 239, ncost: 1566.8825615903725  
Run: 7, iteration: 2/100, moves: 72, ncost: 1476.5778093300337  
Run: 7, iteration: 3/100, moves: 42, ncost: 1443.7837687445374  
Run: 7, iteration: 4/100, moves: 18, ncost: 1434.5644164892537  
Run: 7, iteration: 5/100, moves: 9, ncost: 1430.7839388093182  
Run: 7, iteration: 6/100, moves: 4, ncost: 1428.4198013781377  
Run: 7, iteration: 7/100, moves: 3, ncost: 1427.602963282796  
Run: 7, iteration: 8/100, moves: 1, ncost: 1427.5278769575514  
Run: 7, iteration: 9/100, moves: 0, ncost: 1427.5278769575514

Init: initializing centroids

Init: initializing clusters

Starting iterations...

Run: 8, iteration: 1/100, moves: 221, ncost: 1576.1071527960255  
Run: 8, iteration: 2/100, moves: 67, ncost: 1529.290390710579  
Run: 8, iteration: 3/100, moves: 22, ncost: 1518.562011736882  
Run: 8, iteration: 4/100, moves: 8, ncost: 1512.6695018932646  
Run: 8, iteration: 5/100, moves: 6, ncost: 1509.7595562348508  
Run: 8, iteration: 6/100, moves: 0, ncost: 1509.7595562348508

Init: initializing centroids

Init: initializing clusters

Init: initializing centroids

Init: initializing clusters

Init: initializing centroids

Init: initializing clusters

Init: initializing centroids

Init: initializing clusters

Init: initializing centroids

Init: initializing clusters

Starting iterations...

Run: 9, iteration: 1/100, moves: 235, ncost: 1518.0699892751018  
Run: 9, iteration: 2/100, moves: 54, ncost: 1484.1746174661869  
Run: 9, iteration: 3/100, moves: 25, ncost: 1467.922776414938  
Run: 9, iteration: 4/100, moves: 17, ncost: 1461.2633818256495  
Run: 9, iteration: 5/100, moves: 3, ncost: 1460.752458548977  
Run: 9, iteration: 6/100, moves: 8, ncost: 1453.950990282668  
Run: 9, iteration: 7/100, moves: 7, ncost: 1450.051603383128  
Run: 9, iteration: 8/100, moves: 9, ncost: 1439.067586646025  
Run: 9, iteration: 9/100, moves: 3, ncost: 1436.815888635144  
Run: 9, iteration: 10/100, moves: 6, ncost: 1433.3822259904146  
Run: 9, iteration: 11/100, moves: 2, ncost: 1432.1319245685213  
Run: 9, iteration: 12/100, moves: 0, ncost: 1432.1319245685213

Init: initializing centroids

Init: initializing clusters

Init: initializing centroids

Init: initializing clusters

Init: initializing centroids

Init: initializing clusters

Init: initializing centroids

Init: initializing clusters

Init: initializing centroids

Init: initializing clusters

Starting iterations...

Run: 10, iteration: 1/100, moves: 222, ncost: 1439.1337956340399  
Run: 10, iteration: 2/100, moves: 59, ncost: 1399.8096401373612  
Run: 10, iteration: 3/100, moves: 20, ncost: 1390.0395496578951

68%|

| 19/28 [01:06<00:31, 3.55s/it]

```
Run: 10, iteration: 4/100, moves: 12, ncost: 1384.7300772323651
Run: 10, iteration: 5/100, moves: 2, ncost: 1384.0321678424343
Run: 10, iteration: 6/100, moves: 1, ncost: 1383.7414847782832
Run: 10, iteration: 7/100, moves: 0, ncost: 1383.7414847782832
Best run was number 10
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 1, iteration: 1/100, moves: 215, ncost: 1478.2138187523724
Run: 1, iteration: 2/100, moves: 87, ncost: 1409.0466952835961
Run: 1, iteration: 3/100, moves: 43, ncost: 1380.875325037677
Run: 1, iteration: 4/100, moves: 27, ncost: 1362.171922237661
Run: 1, iteration: 5/100, moves: 9, ncost: 1358.905849568307
Run: 1, iteration: 6/100, moves: 9, ncost: 1355.8016709805647
Run: 1, iteration: 7/100, moves: 7, ncost: 1353.576408323832
Run: 1, iteration: 8/100, moves: 7, ncost: 1350.4746245387391
Run: 1, iteration: 9/100, moves: 3, ncost: 1349.3418324976572
Run: 1, iteration: 10/100, moves: 4, ncost: 1346.1843773371063
Run: 1, iteration: 11/100, moves: 3, ncost: 1344.1226718244807
Run: 1, iteration: 12/100, moves: 2, ncost: 1342.9643928614041
Run: 1, iteration: 13/100, moves: 0, ncost: 1342.9643928614041
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 2, iteration: 1/100, moves: 224, ncost: 1479.1493006626113
Run: 2, iteration: 2/100, moves: 96, ncost: 1402.3199139628407
Run: 2, iteration: 3/100, moves: 30, ncost: 1382.6782175447117
Run: 2, iteration: 4/100, moves: 17, ncost: 1375.4714784308412
Run: 2, iteration: 5/100, moves: 15, ncost: 1363.1140180208856
Run: 2, iteration: 6/100, moves: 8, ncost: 1358.4783737742885
Run: 2, iteration: 7/100, moves: 5, ncost: 1356.7668861323377
Run: 2, iteration: 8/100, moves: 12, ncost: 1350.076817565423
Run: 2, iteration: 9/100, moves: 8, ncost: 1345.7136794864625
Run: 2, iteration: 10/100, moves: 13, ncost: 1339.7345800808353
Run: 2, iteration: 11/100, moves: 6, ncost: 1338.523547057832
Run: 2, iteration: 12/100, moves: 0, ncost: 1338.523547057832
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 3, iteration: 1/100, moves: 218, ncost: 1470.7266619299724
Run: 3, iteration: 2/100, moves: 68, ncost: 1420.2654732341077
Run: 3, iteration: 3/100, moves: 20, ncost: 1408.8732876304941
Run: 3, iteration: 4/100, moves: 9, ncost: 1404.7906447180121
Run: 3, iteration: 5/100, moves: 8, ncost: 1399.1919655451363
Run: 3, iteration: 6/100, moves: 4, ncost: 1398.164984015968
Run: 3, iteration: 7/100, moves: 1, ncost: 1397.992483395673
Run: 3, iteration: 8/100, moves: 0, ncost: 1397.992483395673
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
```

```
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 4, iteration: 1/100, moves: 221, ncost: 1501.463640248319
Run: 4, iteration: 2/100, moves: 68, ncost: 1450.1573651899698
Run: 4, iteration: 3/100, moves: 27, ncost: 1429.902935118585
Run: 4, iteration: 4/100, moves: 21, ncost: 1420.3939441229588
Run: 4, iteration: 5/100, moves: 7, ncost: 1418.5766440112743
Run: 4, iteration: 6/100, moves: 2, ncost: 1418.4831403225896
Run: 4, iteration: 7/100, moves: 0, ncost: 1418.4831403225896
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 5, iteration: 1/100, moves: 220, ncost: 1492.407786636594
Run: 5, iteration: 2/100, moves: 89, ncost: 1423.1871274091493
Run: 5, iteration: 3/100, moves: 29, ncost: 1397.6601388496208
Run: 5, iteration: 4/100, moves: 17, ncost: 1385.3829590156945
Run: 5, iteration: 5/100, moves: 10, ncost: 1381.7448604743024
Run: 5, iteration: 6/100, moves: 6, ncost: 1378.1567893659167
Run: 5, iteration: 7/100, moves: 3, ncost: 1376.3344588212806
Run: 5, iteration: 8/100, moves: 3, ncost: 1375.4098553587617
Run: 5, iteration: 9/100, moves: 3, ncost: 1374.7195766941322
Run: 5, iteration: 10/100, moves: 0, ncost: 1374.7195766941322
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 216, ncost: 1535.0772165343299
Run: 6, iteration: 2/100, moves: 56, ncost: 1491.7854436628447
Run: 6, iteration: 3/100, moves: 31, ncost: 1468.1279917719626
Run: 6, iteration: 4/100, moves: 22, ncost: 1453.9462485096496
Run: 6, iteration: 5/100, moves: 16, ncost: 1446.2173068154698
Run: 6, iteration: 6/100, moves: 19, ncost: 1434.7981674296984
Run: 6, iteration: 7/100, moves: 22, ncost: 1417.4439705925176
Run: 6, iteration: 8/100, moves: 20, ncost: 1406.704351299485
Run: 6, iteration: 9/100, moves: 10, ncost: 1403.8553502330376
Run: 6, iteration: 10/100, moves: 3, ncost: 1403.3373872623097
Run: 6, iteration: 11/100, moves: 3, ncost: 1402.6100811701558
Run: 6, iteration: 12/100, moves: 1, ncost: 1402.3057367158585
Run: 6, iteration: 13/100, moves: 0, ncost: 1402.3057367158585
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 186, ncost: 1504.597378457814
Run: 7, iteration: 2/100, moves: 45, ncost: 1467.2176074119768
Run: 7, iteration: 3/100, moves: 41, ncost: 1439.5378620938104
Run: 7, iteration: 4/100, moves: 23, ncost: 1428.8303472675982
Run: 7, iteration: 5/100, moves: 6, ncost: 1426.298968262742
Run: 7, iteration: 6/100, moves: 9, ncost: 1424.2381260344664
Run: 7, iteration: 7/100, moves: 4, ncost: 1423.4074483287484
Run: 7, iteration: 8/100, moves: 0, ncost: 1423.4074483287484
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 242, ncost: 1527.4656596412424
Run: 8, iteration: 2/100, moves: 90, ncost: 1439.1934613799142
Run: 8, iteration: 3/100, moves: 25, ncost: 1421.1583992245432
```

```
| 71%|███████████  
| 20/28 [01:09<00:28, 3.54s/it]
```

[illegible]



```
Init: initializing clusters
Starting iterations...
Run: 3, iteration: 1/100, moves: 227, ncost: 1464.805769009219
Run: 3, iteration: 2/100, moves: 81, ncost: 1377.1066784749983
Run: 3, iteration: 3/100, moves: 25, ncost: 1360.5386322605862
Run: 3, iteration: 4/100, moves: 17, ncost: 1353.141140364713
Run: 3, iteration: 5/100, moves: 9, ncost: 1348.4958470469387
Run: 3, iteration: 6/100, moves: 4, ncost: 1345.8992981634065
Run: 3, iteration: 7/100, moves: 2, ncost: 1345.5630025453768
Run: 3, iteration: 8/100, moves: 0, ncost: 1345.5630025453768
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
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Init: initializing centroids
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Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 4, iteration: 1/100, moves: 233, ncost: 1545.917708899066
Run: 4, iteration: 2/100, moves: 86, ncost: 1461.7718325754681
Run: 4, iteration: 3/100, moves: 56, ncost: 1422.2879215995424
Run: 4, iteration: 4/100, moves: 12, ncost: 1417.5781948816477
Run: 4, iteration: 5/100, moves: 10, ncost: 1412.1646330872145
Run: 4, iteration: 6/100, moves: 23, ncost: 1397.268453707948
Run: 4, iteration: 7/100, moves: 16, ncost: 1391.2579347391988
Run: 4, iteration: 8/100, moves: 12, ncost: 1387.7157005956299
Run: 4, iteration: 9/100, moves: 10, ncost: 1382.6326796072096
Run: 4, iteration: 10/100, moves: 9, ncost: 1378.5442721404104
Run: 4, iteration: 11/100, moves: 14, ncost: 1372.9531483853684
Run: 4, iteration: 12/100, moves: 6, ncost: 1370.2988998122712
Run: 4, iteration: 13/100, moves: 7, ncost: 1367.374896851692
Run: 4, iteration: 14/100, moves: 9, ncost: 1363.5301398638574
Run: 4, iteration: 15/100, moves: 4, ncost: 1362.7426089114913
Run: 4, iteration: 16/100, moves: 1, ncost: 1362.6745260489313
Run: 4, iteration: 17/100, moves: 0, ncost: 1362.6745260489313
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 5, iteration: 1/100, moves: 223, ncost: 1522.0558551053784
Run: 5, iteration: 2/100, moves: 87, ncost: 1435.7286495955207
Run: 5, iteration: 3/100, moves: 64, ncost: 1390.7924683944132
Run: 5, iteration: 4/100, moves: 48, ncost: 1353.6523126694376
Run: 5, iteration: 5/100, moves: 22, ncost: 1340.7243331171258
Run: 5, iteration: 6/100, moves: 9, ncost: 1336.9848830883332
Run: 5, iteration: 7/100, moves: 0, ncost: 1336.9848830883332
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 169, ncost: 1461.0371148253696
Run: 6, iteration: 2/100, moves: 69, ncost: 1419.8977295629834
Run: 6, iteration: 3/100, moves: 30, ncost: 1404.2437428563553
Run: 6, iteration: 4/100, moves: 17, ncost: 1393.3150575823934
Run: 6, iteration: 5/100, moves: 16, ncost: 1387.1296845862553
Run: 6, iteration: 6/100, moves: 6, ncost: 1386.0719101072489
Run: 6, iteration: 7/100, moves: 2, ncost: 1385.9435052043527
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```
Run: 6, iteration: 8/100, moves: 0, ncost: 1385.9435052043527
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
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Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 245, ncost: 1473.5629273592956
Run: 7, iteration: 2/100, moves: 81, ncost: 1397.4279257739458
Run: 7, iteration: 3/100, moves: 42, ncost: 1351.2245447354933
Run: 7, iteration: 4/100, moves: 20, ncost: 1333.5842187457542
Run: 7, iteration: 5/100, moves: 8, ncost: 1328.9860243503538
Run: 7, iteration: 6/100, moves: 3, ncost: 1328.1996892990999
Run: 7, iteration: 7/100, moves: 0, ncost: 1328.1996892990999
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 217, ncost: 1493.301993786435
Run: 8, iteration: 2/100, moves: 77, ncost: 1448.4630664605916
Run: 8, iteration: 3/100, moves: 27, ncost: 1436.281379556081
Run: 8, iteration: 4/100, moves: 26, ncost: 1414.840583781454
Run: 8, iteration: 5/100, moves: 18, ncost: 1401.0825852642538
Run: 8, iteration: 6/100, moves: 14, ncost: 1387.6264576683918
Run: 8, iteration: 7/100, moves: 8, ncost: 1383.2603564809176
Run: 8, iteration: 8/100, moves: 7, ncost: 1380.2092112659707
Run: 8, iteration: 9/100, moves: 1, ncost: 1380.0597206383713
Run: 8, iteration: 10/100, moves: 0, ncost: 1380.0597206383713
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 217, ncost: 1481.415905778408
Run: 9, iteration: 2/100, moves: 84, ncost: 1402.5869049690787
Run: 9, iteration: 3/100, moves: 43, ncost: 1374.5673663484786
Run: 9, iteration: 4/100, moves: 32, ncost: 1354.7033112395495
Run: 9, iteration: 5/100, moves: 14, ncost: 1350.1856679702034
Run: 9, iteration: 6/100, moves: 4, ncost: 1349.4603644440854
Run: 9, iteration: 7/100, moves: 1, ncost: 1349.197915721938
```

```
Run: 9, iteration: 8/100, moves: 0, ncost: 1349.197915721938
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 10, iteration: 1/100, moves: 269, ncost: 1476.5160484217795
Run: 10, iteration: 2/100, moves: 65, ncost: 1428.1102246147248
Run: 10, iteration: 3/100, moves: 33, ncost: 1396.6679817637776
Run: 10, iteration: 4/100, moves: 17, ncost: 1383.3259374798297
Run: 10, iteration: 5/100, moves: 18, ncost: 1372.2587488249285
Run: 10, iteration: 6/100, moves: 5, ncost: 1371.0675179172913
Run: 10, iteration: 7/100, moves: 4, ncost: 1370.1328952337153
Run: 10, iteration: 8/100, moves: 3, ncost: 1369.2330045385454
```

75%|

| 21/28 [01:13&lt;00:25, 3.70s/it]

[illegible]

[illegible]

```
Run: 5, iteration: 6/100, moves: 0, ncost: 1355.601383588045
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 220, ncost: 1397.5558438327753
Run: 6, iteration: 2/100, moves: 98, ncost: 1319.9162970287416
Run: 6, iteration: 3/100, moves: 23, ncost: 1307.323159732182
Run: 6, iteration: 4/100, moves: 10, ncost: 1304.0700382962514
Run: 6, iteration: 5/100, moves: 0, ncost: 1304.0700382962514
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
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Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 7, iteration: 1/100, moves: 240, ncost: 1464.6052098153255
Run: 7, iteration: 2/100, moves: 68, ncost: 1406.9860964561917
Run: 7, iteration: 3/100, moves: 37, ncost: 1385.7249715295957
Run: 7, iteration: 4/100, moves: 10, ncost: 1381.6077345212245
Run: 7, iteration: 5/100, moves: 0, ncost: 1381.6077345212245
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 263, ncost: 1481.8151621107324
Run: 8, iteration: 2/100, moves: 87, ncost: 1387.3900861722968
Run: 8, iteration: 3/100, moves: 42, ncost: 1357.3043131282825
Run: 8, iteration: 4/100, moves: 23, ncost: 1346.1736326025605
Run: 8, iteration: 5/100, moves: 12, ncost: 1339.0821342545453
Run: 8, iteration: 6/100, moves: 12, ncost: 1330.9070521864367
Run: 8, iteration: 7/100, moves: 8, ncost: 1325.6037425219638
Run: 8, iteration: 8/100, moves: 5, ncost: 1323.040809276488
Run: 8, iteration: 9/100, moves: 3, ncost: 1322.396281101687
Run: 8, iteration: 10/100, moves: 0, ncost: 1322.396281101687
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 9, iteration: 1/100, moves: 216, ncost: 1455.9095941012918
Run: 9, iteration: 2/100, moves: 90, ncost: 1371.1024663400663
Run: 9, iteration: 3/100, moves: 25, ncost: 1349.7708301216946
```

[illegible]

```
Run: 10, iteration: 9/100, moves: 1, ncost: 1318.863242936461
Run: 10, iteration: 10/100, moves: 1, ncost: 1318.6096331519686
Run: 10, iteration: 11/100, moves: 0, ncost: 1318.6096331519686
Best run was number 9
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 1, iteration: 1/100, moves: 226, ncost: 1380.069958435259
Run: 1, iteration: 2/100, moves: 81, ncost: 1308.219382034667
Run: 1, iteration: 3/100, moves: 34, ncost: 1286.6507271025584
Run: 1, iteration: 4/100, moves: 22, ncost: 1276.9004041724868
Run: 1, iteration: 5/100, moves: 11, ncost: 1273.662118935039
Run: 1, iteration: 6/100, moves: 9, ncost: 1267.7695636804513
Run: 1, iteration: 7/100, moves: 4, ncost: 1266.5788760653436
Run: 1, iteration: 8/100, moves: 6, ncost: 1264.2809359411824
Run: 1, iteration: 9/100, moves: 7, ncost: 1259.2055255978496
Run: 1, iteration: 10/100, moves: 3, ncost: 1258.2487192329693
Run: 1, iteration: 11/100, moves: 0, ncost: 1258.2487192329693
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 2, iteration: 1/100, moves: 213, ncost: 1458.3026633309532
Run: 2, iteration: 2/100, moves: 100, ncost: 1343.5324924820518
Run: 2, iteration: 3/100, moves: 47, ncost: 1313.2218504940377
Run: 2, iteration: 4/100, moves: 13, ncost: 1306.7988990537744
Run: 2, iteration: 5/100, moves: 10, ncost: 1303.4156101557066
Run: 2, iteration: 6/100, moves: 3, ncost: 1302.6217582643599
Run: 2, iteration: 7/100, moves: 3, ncost: 1301.8681279908071
Run: 2, iteration: 8/100, moves: 3, ncost: 1301.0064596532452
Run: 2, iteration: 9/100, moves: 1, ncost: 1300.9259541340762
Run: 2, iteration: 10/100, moves: 0, ncost: 1300.9259541340762
Init: initializing centroids
Init: initializing clusters
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Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 3, iteration: 1/100, moves: 233, ncost: 1441.6392819767682
Run: 3, iteration: 2/100, moves: 81, ncost: 1377.1466681732113
Run: 3, iteration: 3/100, moves: 33, ncost: 1356.87251856439
Run: 3, iteration: 4/100, moves: 15, ncost: 1350.0249677685927
Run: 3, iteration: 5/100, moves: 9, ncost: 1345.827007533998
Run: 3, iteration: 6/100, moves: 2, ncost: 1344.904674695623
Run: 3, iteration: 7/100, moves: 3, ncost: 1344.0953119356918
Run: 3, iteration: 8/100, moves: 1, ncost: 1343.9090359232978
Run: 3, iteration: 9/100, moves: 0, ncost: 1343.9090359232978
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
Init: initializing centroids
Init: initializing clusters
```



localhost:8888/nbconvert/html/Documents/SRM/master thesis/data analysis/model/kprototype all var mobility final 250524.ipynb?download=false 73/183

```
Starting iterations...  
Run: 8, iteration: 1/100, moves: 222, ncost: 1429.176965027096  
Run: 8, iteration: 2/100, moves: 83, ncost: 1359.5651976946006  
Run: 8, iteration: 3/100, moves: 43, ncost: 1329.1783428062374  
Run: 8, iteration: 4/100, moves: 26, ncost: 1307.9470066570448  
Run: 8, iteration: 5/100, moves: 24, ncost: 1292.9347563703427  
Run: 8, iteration: 6/100, moves: 16, ncost: 1286.320970537198  
Run: 8, iteration: 7/100, moves: 16, ncost: 1276.316046150514  
Run: 8, iteration: 8/100, moves: 9, ncost: 1274.3745842126862  
Run: 8, iteration: 9/100, moves: 4, ncost: 1272.9166028743816  
Run: 8, iteration: 10/100, moves: 0, ncost: 1272.9166028743816  
Init: initializing centroids  
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Init: initializing clusters  
Starting iterations...  
Run: 9, iteration: 1/100, moves: 238, ncost: 1452.6719157219466  
Run: 9, iteration: 2/100, moves: 71, ncost: 1376.091147219315  
Run: 9, iteration: 3/100, moves: 32, ncost: 1337.5441384117755  
Run: 9, iteration: 4/100, moves: 9, ncost: 1333.5961913331853  
Run: 9, iteration: 5/100, moves: 16, ncost: 1311.3738785797987  
Run: 9, iteration: 6/100, moves: 5, ncost: 1308.7607636966586  
Run: 9, iteration: 7/100, moves: 0, ncost: 1308.7607636966586
```

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Init: initializing centroids  
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Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 10, iteration: 1/100, moves: 264, ncost: 1396.5139926546422  
Run: 10, iteration: 2/100, moves: 91, ncost: 1326.5423891362034  
Run: 10, iteration: 3/100, moves: 31, ncost: 1313.861953875185  
Run: 10, iteration: 4/100, moves: 15, ncost: 1309.2471616861949  
Run: 10, iteration: 5/100, moves: 5, ncost: 1307.906006474121
```

82%

23/28 [01:21<00:19, 3.86s/it]

```
Run: 10, iteration: 6/100, moves: 0, ncost: 1307.906006474121  
Best run was number 1  
Initialization method and algorithm are deterministic. Setting n_init to 1.  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
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Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 1, iteration: 1/100, moves: 231, ncost: 1375.9406395785877  
Run: 1, iteration: 2/100, moves: 90, ncost: 1293.9672321782432  
Run: 1, iteration: 3/100, moves: 27, ncost: 1282.0630894867913  
Run: 1, iteration: 4/100, moves: 15, ncost: 1276.994385601215  
Run: 1, iteration: 5/100, moves: 2, ncost: 1276.821508877411  
Run: 1, iteration: 6/100, moves: 0, ncost: 1276.821508877411  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 2, iteration: 1/100, moves: 226, ncost: 1382.7792254457368  
Run: 2, iteration: 2/100, moves: 105, ncost: 1292.9193659460864  
Run: 2, iteration: 3/100, moves: 32, ncost: 1279.498991964671  
Run: 2, iteration: 4/100, moves: 16, ncost: 1271.5142590466048  
Run: 2, iteration: 5/100, moves: 15, ncost: 1261.7359859844573  
Run: 2, iteration: 6/100, moves: 8, ncost: 1255.2211307626756  
Run: 2, iteration: 7/100, moves: 9, ncost: 1251.438854620253  
Run: 2, iteration: 8/100, moves: 4, ncost: 1249.6087007696653  
Run: 2, iteration: 9/100, moves: 3, ncost: 1248.7348528764164  
Run: 2, iteration: 10/100, moves: 0, ncost: 1248.7348528764164  
Init: initializing centroids  
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[illegible]

[illegible]

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Init: initializing centroids
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Init: initializing clusters
Starting iterations...
Run: 6, iteration: 1/100, moves: 239, ncost: 1419.5056609616101
Run: 6, iteration: 2/100, moves: 87, ncost: 1319.9606631323963
Run: 6, iteration: 3/100, moves: 32, ncost: 1291.8176474112743
Run: 6, iteration: 4/100, moves: 24, ncost: 1281.6380888843687
Run: 6, iteration: 5/100, moves: 8, ncost: 1277.2622182522464
Run: 6, iteration: 6/100, moves: 7, ncost: 1274.7885259716365
Run: 6, iteration: 7/100, moves: 3, ncost: 1273.610758144499
Run: 6, iteration: 8/100, moves: 1, ncost: 1273.2537549230763
Run: 6, iteration: 9/100, moves: 4, ncost: 1272.1209013209152
Run: 6, iteration: 10/100, moves: 4, ncost: 1271.0752750425247
Run: 6, iteration: 11/100, moves: 4, ncost: 1269.3163282479138
Run: 6, iteration: 12/100, moves: 1, ncost: 1269.2103186105342
Run: 6, iteration: 13/100, moves: 0, ncost: 1269.2103186105342
Init: initializing centroids
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Starting iterations...
Run: 7, iteration: 1/100, moves: 218, ncost: 1369.3556550232154
Run: 7, iteration: 2/100, moves: 75, ncost: 1297.327068091741
Run: 7, iteration: 3/100, moves: 43, ncost: 1277.037002268194
Run: 7, iteration: 4/100, moves: 12, ncost: 1269.6242062007684
Run: 7, iteration: 5/100, moves: 20, ncost: 1261.1547212996213
Run: 7, iteration: 6/100, moves: 5, ncost: 1258.6996502834957
Run: 7, iteration: 7/100, moves: 6, ncost: 1254.5878618618626
Run: 7, iteration: 8/100, moves: 3, ncost: 1253.559177400871
Run: 7, iteration: 9/100, moves: 3, ncost: 1252.8431575562438
Run: 7, iteration: 10/100, moves: 5, ncost: 1250.9666185227652
Run: 7, iteration: 11/100, moves: 1, ncost: 1250.7155973167196
Run: 7, iteration: 12/100, moves: 0, ncost: 1250.7155973167196
Init: initializing centroids
Init: initializing clusters
Starting iterations...
Run: 8, iteration: 1/100, moves: 218, ncost: 1417.9684717034793
Run: 8, iteration: 2/100, moves: 67, ncost: 1343.4375347885232
Run: 8, iteration: 3/100, moves: 38, ncost: 1310.5216010647528
Run: 8, iteration: 4/100, moves: 29, ncost: 1292.415638217348
Run: 8, iteration: 5/100, moves: 21, ncost: 1274.033237472297
Run: 8, iteration: 6/100, moves: 12, ncost: 1270.297705281068
Run: 8, iteration: 7/100, moves: 11, ncost: 1265.9770663237416
Run: 8, iteration: 8/100, moves: 7, ncost: 1264.1852089208815
Run: 8, iteration: 9/100, moves: 1, ncost: 1263.893012875564
Run: 8, iteration: 10/100, moves: 5, ncost: 1262.8517897733934
Run: 8, iteration: 11/100, moves: 1, ncost: 1262.7680798677193
Run: 8, iteration: 12/100, moves: 0, ncost: 1262.7680798677193
Init: initializing centroids
Init: initializing clusters
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[illegible]



[illegible]

```
Run: 1, iteration: 1/100, moves: 262, ncost: 1330.9188332442825
Run: 1, iteration: 2/100, moves: 59, ncost: 1300.3113567804699
Run: 1, iteration: 3/100, moves: 29, ncost: 1282.5450630450391
Run: 1, iteration: 4/100, moves: 22, ncost: 1274.3519741727794
Run: 1, iteration: 5/100, moves: 8, ncost: 1272.3521479286755
Run: 1, iteration: 6/100, moves: 7, ncost: 1269.695538666048
Run: 1, iteration: 7/100, moves: 2, ncost: 1268.9820320202514
Run: 1, iteration: 8/100, moves: 1, ncost: 1268.7327950227366
Run: 1, iteration: 9/100, moves: 0, ncost: 1268.7327950227366
Init: initializing centroids
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Starting iterations...  
Run: 2, iteration: 1/100, moves: 221, ncost: 1526.5984657075105  
Run: 2, iteration: 2/100, moves: 76, ncost: 1469.1099440348648  
Run: 2, iteration: 3/100, moves: 54, ncost: 1407.3692964776835  
Run: 2, iteration: 4/100, moves: 65, ncost: 1349.1636244883853  
Run: 2, iteration: 5/100, moves: 27, ncost: 1337.6079754201137  
Run: 2, iteration: 6/100, moves: 6, ncost: 1334.5357138066347  
Run: 2, iteration: 7/100, moves: 9, ncost: 1328.4344320068635  
Run: 2, iteration: 8/100, moves: 11, ncost: 1324.2400068580405  
Run: 2, iteration: 9/100, moves: 4, ncost: 1323.1677384338072  
Run: 2, iteration: 10/100, moves: 3, ncost: 1322.1820588406051  
Run: 2, iteration: 11/100, moves: 1, ncost: 1322.0948763828521  
Run: 2, iteration: 12/100, moves: 0, ncost: 1322.0948763828521  
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Starting iterations...  
Run: 3, iteration: 1/100, moves: 272, ncost: 1325.6781128967718  
Run: 3, iteration: 2/100, moves: 74, ncost: 1264.486622075028  
Run: 3, iteration: 3/100, moves: 33, ncost: 1248.6098258596735  
Run: 3, iteration: 4/100, moves: 13, ncost: 1243.9919666589972  
Run: 3, iteration: 5/100, moves: 3, ncost: 1243.3557139057566  
Run: 3, iteration: 6/100, moves: 0, ncost: 1243.3557139057566  
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Starting iterations...
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Run: 4, iteration: 1/100, moves: 213, ncost: 1361.922028272396  
Run: 4, iteration: 2/100, moves: 95, ncost: 1265.5661022672482  
Run: 4, iteration: 3/100, moves: 31, ncost: 1250.200627208581  
Run: 4, iteration: 4/100, moves: 11, ncost: 1244.1235024288505  
Run: 4, iteration: 5/100, moves: 16, ncost: 1237.9816228890206  
Run: 4, iteration: 6/100, moves: 14, ncost: 1233.5862367792827  
Run: 4, iteration: 7/100, moves: 6, ncost: 1231.5755815362418  
Run: 4, iteration: 8/100, moves: 5, ncost: 1230.6755807707273  
Run: 4, iteration: 9/100, moves: 2, ncost: 1230.459128362388  
Run: 4, iteration: 10/100, moves: 0, ncost: 1230.459128362388  
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Starting iterations...  
Run: 5, iteration: 1/100, moves: 204, ncost: 1349.0774370767344  
Run: 5, iteration: 2/100, moves: 84, ncost: 1282.1995487253596  
Run: 5, iteration: 3/100, moves: 33, ncost: 1262.3834383463113  
Run: 5, iteration: 4/100, moves: 20, ncost: 1253.2446413951116  
Run: 5, iteration: 5/100, moves: 12, ncost: 1247.413682741683  
Run: 5, iteration: 6/100, moves: 1, ncost: 1247.3132416299213  
Run: 5, iteration: 7/100, moves: 0, ncost: 1247.3132416299213  
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Starting iterations...  
Run: 6, iteration: 1/100, moves: 267, ncost: 1399.322869342771
```

Run: 6, iteration: 2/100, moves: 116, ncost: 1287.1245381335832  
Run: 6, iteration: 3/100, moves: 46, ncost: 1255.625008256174  
Run: 6, iteration: 4/100, moves: 18, ncost: 1247.972462944678  
Run: 6, iteration: 5/100, moves: 5, ncost: 1246.7829259740301  
Run: 6, iteration: 6/100, moves: 1, ncost: 1246.2341669894781  
Run: 6, iteration: 7/100, moves: 0, ncost: 1246.2341669894781  
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Starting iterations...  
Run: 7, iteration: 1/100, moves: 213, ncost: 1401.620216985823  
Run: 7, iteration: 2/100, moves: 91, ncost: 1298.4942154964265  
Run: 7, iteration: 3/100, moves: 57, ncost: 1261.0975809253596  
Run: 7, iteration: 4/100, moves: 24, ncost: 1250.4299064697161  
Run: 7, iteration: 5/100, moves: 15, ncost: 1245.052711182424  
Run: 7, iteration: 6/100, moves: 7, ncost: 1240.979244587931  
Run: 7, iteration: 7/100, moves: 2, ncost: 1240.0373217760368  
Run: 7, iteration: 8/100, moves: 0, ncost: 1240.0373217760368  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 8, iteration: 1/100, moves: 209, ncost: 1334.508090015728  
Run: 8, iteration: 2/100, moves: 86, ncost: 1261.1738625769235  
Run: 8, iteration: 3/100, moves: 35, ncost: 1243.48659314761  
Run: 8, iteration: 4/100, moves: 18, ncost: 1238.0042031611083  
Run: 8, iteration: 5/100, moves: 10, ncost: 1230.3530855212646  
Run: 8, iteration: 6/100, moves: 7, ncost: 1227.4481441739276  
Run: 8, iteration: 7/100, moves: 2, ncost: 1227.240849310817  
Run: 8, iteration: 8/100, moves: 0, ncost: 1227.240849310817  
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Starting iterations...  
Run: 9, iteration: 1/100, moves: 244, ncost: 1358.3524955376333  
Run: 9, iteration: 2/100, moves: 78, ncost: 1266.982156866639  
Run: 9, iteration: 3/100, moves: 33, ncost: 1244.8033760300445
```

```
Run: 9, iteration: 4/100, moves: 31, ncost: 1228.100379338491
Run: 9, iteration: 5/100, moves: 6, ncost: 1223.0147675471255
Run: 9, iteration: 6/100, moves: 2, ncost: 1220.6618205552338
Run: 9, iteration: 7/100, moves: 5, ncost: 1217.5549742756964
Run: 9, iteration: 8/100, moves: 3, ncost: 1215.7076505045804
Run: 9, iteration: 9/100, moves: 3, ncost: 1214.9385358908585
Run: 9, iteration: 10/100, moves: 0, ncost: 1214.9385358908585
Init: initializing centroids
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Starting iterations...
Run: 10, iteration: 1/100, moves: 245, ncost: 1374.2180787285483
Run: 10, iteration: 2/100, moves: 69, ncost: 1302.0852873120482
Run: 10, iteration: 3/100, moves: 35, ncost: 1283.1470224520676
Run: 10, iteration: 4/100, moves: 17, ncost: 1265.1769152291997
Run: 10, iteration: 5/100, moves: 11, ncost: 1257.4804309919414
Run: 10, iteration: 6/100, moves: 15, ncost: 1247.0580246995687
Run: 10, iteration: 7/100, moves: 7, ncost: 1244.7841698378058
Run: 10, iteration: 8/100, moves: 12, ncost: 1239.8912490919724
Run: 10, iteration: 9/100, moves: 11, ncost: 1236.6032315594982
Run: 10, iteration: 10/100, moves: 11, ncost: 1229.2156482494272
Run: 10, iteration: 11/100, moves: 17, ncost: 1221.4792456164623
Run: 10, iteration: 12/100, moves: 10, ncost: 1218.4461015143531
```

89%

| 25/28 [01:32<00:13, 4.64s/it]

```
Run: 10, iteration: 13/100, moves: 2, ncost: 1217.937289243452
Run: 10, iteration: 14/100, moves: 0, ncost: 1217.937289243452
Best run was number 9
Initialization method and algorithm are deterministic. Setting n_init to 1.
Init: initializing centroids
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Starting iterations...
Run: 1, iteration: 1/100, moves: 224, ncost: 1467.4024494061134
Run: 1, iteration: 2/100, moves: 95, ncost: 1384.173234449456
Run: 1, iteration: 3/100, moves: 52, ncost: 1335.4012075026978
Run: 1, iteration: 4/100, moves: 28, ncost: 1310.582453770931
Run: 1, iteration: 5/100, moves: 18, ncost: 1288.0571991199945
Run: 1, iteration: 6/100, moves: 17, ncost: 1251.7605889162794
Run: 1, iteration: 7/100, moves: 2, ncost: 1251.5278091264393
Run: 1, iteration: 8/100, moves: 0, ncost: 1251.5278091264393
Init: initializing centroids
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Starting iterations...
Run: 2, iteration: 1/100, moves: 229, ncost: 1310.7481556925923
Run: 2, iteration: 2/100, moves: 63, ncost: 1263.134960131574
Run: 2, iteration: 3/100, moves: 46, ncost: 1219.8261664398756
Run: 2, iteration: 4/100, moves: 14, ncost: 1210.1222257128297
Run: 2, iteration: 5/100, moves: 8, ncost: 1207.6587348483044
Run: 2, iteration: 6/100, moves: 5, ncost: 1206.6119825597953
Run: 2, iteration: 7/100, moves: 0, ncost: 1206.6119825597953
Init: initializing centroids
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Starting iterations...
Run: 3, iteration: 1/100, moves: 237, ncost: 1325.1513388403305
Run: 3, iteration: 2/100, moves: 94, ncost: 1245.4670898554716
Run: 3, iteration: 3/100, moves: 34, ncost: 1226.2516035058056
Run: 3, iteration: 4/100, moves: 15, ncost: 1220.0576977164058
```



[illegible]

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Starting iterations...  
Run: 7, iteration: 1/100, mo  
Run: 7, iteration: 2/100, mo  
Run: 7, iteration: 3/100, mo  
Run: 7, iteration: 4/100, mo  
Run: 7, iteration: 5/100, mo  
Run: 7, iteration: 6/100, mo  
Run: 7, iteration: 7/100, mo  
Run: 7, iteration: 8/100, mo  
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Starting iterations...  
Run: 8, iteration: 1/100, mo  
Run: 8, iteration: 2/100, mo  
Run: 8, iteration: 3/100, mo  
Run: 8, iteration: 4/100, mo  
Run: 8, iteration: 5/100, mo  
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[illegible]

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Run: 10, iteration: 2/100, moves: 67, ncost: 1240.6591264323636
Run: 10, iteration: 3/100, moves: 26, ncost: 1220.471519981654
Run: 10, iteration: 4/100, moves: 8, ncost: 1216.6782060050195
Run: 10, iteration: 5/100, moves: 3, ncost: 1216.1583566961924
Run: 10, iteration: 6/100, moves: 1, ncost: 1216.0126527998043
Run: 10, iteration: 7/100, moves: 0, ncost: 1216.0126527998043
Best run was number 2
```

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]





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Init: initializing clusters
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Starting iterations...
Run: 9, iteration: 1/100, moves: 242, ncost: 1282.0660089417715
Run: 9, iteration: 2/100, moves: 77, ncost: 1232.190367203133
Run: 9, iteration: 3/100, moves: 23, ncost: 1221.039606039119
Run: 9, iteration: 4/100, moves: 14, ncost: 1212.180905434548
Run: 9, iteration: 5/100, moves: 4, ncost: 1210.6287441960283
Run: 9, iteration: 6/100, moves: 1, ncost: 1210.376215297111
Run: 9, iteration: 7/100, moves: 0, ncost: 1210.376215297111
Init: initializing centroids
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Starting iterations...
Run: 10, iteration: 1/100, moves: 257, ncost: 1328.348794080200
Run: 10, iteration: 2/100, moves: 117, ncost: 1214.165324390503
Run: 10, iteration: 3/100, moves: 30, ncost: 1198.0517057277893
```

96%

| 27/28 [01:42<00:05, 5.00s/it]

[illegible]

[illegible]

```
Run: 3, iteration: 10/100, moves: 3, ncost: 1201.9380255903488  
Run: 3, iteration: 11/100, moves: 2, ncost: 1201.2526618972056  
Run: 3, iteration: 12/100, moves: 1, ncost: 1200.9507501880248  
Run: 3, iteration: 13/100, moves: 0, ncost: 1200.9507501880248  
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Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 4, iteration: 1/100, moves: 246, ncost: 1300.9192248212432  
Run: 4, iteration: 2/100, moves: 72, ncost: 1253.1145512461208  
Run: 4, iteration: 3/100, moves: 44, ncost: 1210.1066691591632  
Run: 4, iteration: 4/100, moves: 25, ncost: 1201.276872946608  
Run: 4, iteration: 5/100, moves: 19, ncost: 1193.1518213898844  
Run: 4, iteration: 6/100, moves: 11, ncost: 1190.6712166888394  
Run: 4, iteration: 7/100, moves: 0, ncost: 1190.6712166888394  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
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Init: initializing centroids  
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Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 5, iteration: 1/100, moves: 226, ncost: 1361.3914167209764  
Run: 5, iteration: 2/100, moves: 76, ncost: 1299.4549399921448  
Run: 5, iteration: 3/100, moves: 44, ncost: 1265.5567079919063  
Run: 5, iteration: 4/100, moves: 20, ncost: 1257.8065949728837  
Run: 5, iteration: 5/100, moves: 8, ncost: 1251.1813769644255
```

[illegible]

[illegible]



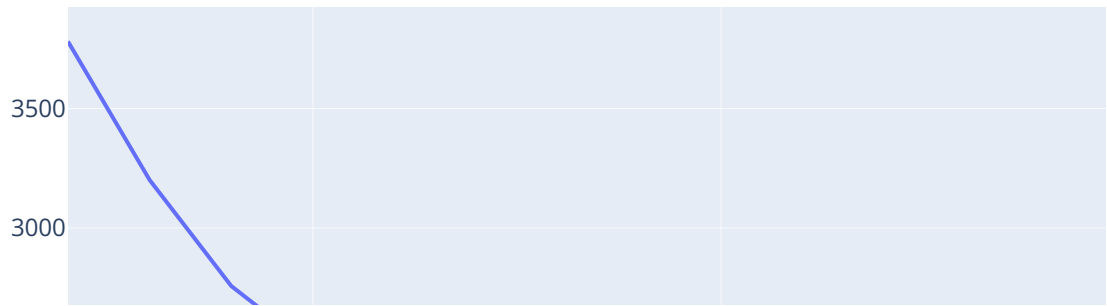


[illegible]

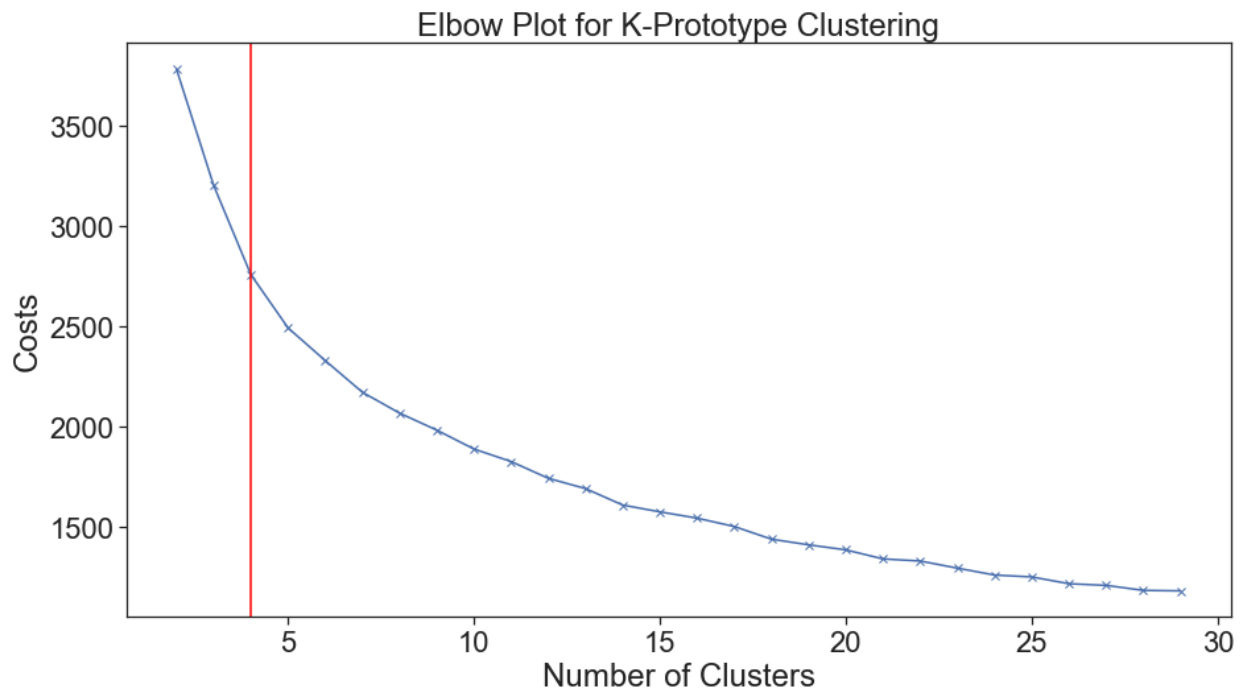
```
Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Init: initializing centroids  
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Init: initializing clusters  
Init: initializing centroids  
Init: initializing clusters  
Starting iterations...  
Run: 10, iteration: 1/100, moves: 217, ncost: 1286.7747172726704  
Run: 10, iteration: 2/100, moves: 79, ncost: 1216.218094782936  
Run: 10, iteration: 3/100, moves: 20, ncost: 1203.1351819999102
```

```
100%|███████████ 28/28 [01:49<00:00, 3.91s/it]
```

```
Run: 10, iteration: 4/100, moves: 15, ncost: 1194.9680864065238  
Run: 10, iteration: 5/100, moves: 15, ncost: 1187.9480411701975  
Run: 10, iteration: 6/100, moves: 7, ncost: 1186.140982685241  
Run: 10, iteration: 7/100, moves: 0, ncost: 1186.140982685241  
Best run was number 8
```



```
In [12]: # Plotting the elbow plot again
plt.figure(figsize= (15,8))
plt.plot(n_clusters, costs, 'bx-')
plt.xlabel('Number of Clusters')
plt.ylabel('Costs')
plt.title('Elbow Plot for K-Prototype Clustering')
plt.axvline(x=4, color='red')
plt.show()
```



In [13]: `kprot_data.head()`

Out[13]:

	age	income	urban_rural_class	no_cars	CO2_cruise	CO2_flight	CO2_public_transport	CO2...
0	1.698314	0.107831	zentral	0.204851	-0.349480	1.148820	-1.614733	
1	1.472446	-1.449330	sehr zentral	1.228155	2.864273	1.302127	0.619298	
2	1.510853	-0.753910	peripher	-1.290552	-0.349480	-0.128851	0.619298	
3	1.985096	-0.226188	sehr zentral	0.204851	-0.349480	1.115121	-1.614733	
4	0.792913	-0.226188	sehr zentral	-1.290552	-0.349480	-1.054372	0.619298	

In [14]: `categorical_columns = [2] #make sure to specify correct indices`

In [15]: `## Running k-prototype`

```
np.random.seed(123)

kproto = KPrototypes(n_clusters= 4, init='Cao', n_jobs = 4)
clusters = kproto.fit_predict(kprot_data, categorical=categorical_columns)
```

In [16]: `pd.Series(clusters).value_counts()`

Out[16]:

```
2    203
1    176
3    145
0     64
dtype: int64
```

In [17]: `#Percentages for each cluster`

```
round(100*pd.Series(clusters).value_counts()/len(clusters),2)
```

```
Out[17]: 2    34.52
1    29.93
3    24.66
0    10.88
dtype: float64
```

```
In [18]: # Cluster Centroids
print(kproto.cluster_centroids_)

[['-0.09824047410892645' '0.18343840284268573' '0.2797064966567219'
  '2.8613654458304603' '0.7547354415956465' '0.13060338692779627'
  '0.3299184655113894' '-0.8013854359071523' 'sehr zentral']
 ['-0.207154244404732732' '0.35541209834096965' '0.5601258030159265'
  '-0.3494797491090647' '0.11644517634663637' '0.6192975147412629'
  '0.5350287977233228' '-0.2283482925997057' 'sehr zentral']
 ['-0.15086085674067082' '-0.49551670963769184' '-1.0521084630889939'
  '-0.34947974910906465' '-0.1084988021445697' '0.5752772132914924'
  '-1.0513184886109046' '0.3537663729592048' 'sehr zentral']
 ['0.5060089049217761' '0.18136072390695743' '0.669618350967122'
  '-0.3494797491090649' '-0.3225666376812573' '-1.6147327838345926'
  '0.6768124344550366' '0.13560961161991397' 'zentral']]
```

```
In [19]: ## Placeholder: within cluster sum of squares
```

```
In [20]: ## Placeholder: distances between cluster centroids
```

```
In [21]: df2['cluster_id'] = clusters
```

```
In [22]: df2_nonscale = df[['age', 'income', 'RLK2022', 'no_cars',
  'CO2_cruise', 'CO2_flight', 'CO2_public_transport', 'CO2_car_total', 'CO2_mot
```

```
In [23]: df2_nonscale['cluster_id'] = clusters
```

C:\Users\leajo\AppData\Local\Temp\ipykernel\_20380\2454060158.py:1: SettingWithCopyWarning:

A value is trying to be set on a copy of a slice from a DataFrame.  
Try using `.loc[row_indexer,col_indexer] = value` instead

See the caveats in the documentation: [https://pandas.pydata.org/pandas-docs/stable/user\\_guide/indexing.html#returning-a-view-versus-a-copy](https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy)

```
In [24]: # Scatterplot: CO2 Total Emission vs Belief difference
```

```
sns.set_style("ticks")

x = df2_nonscale['CO2_mobility']
y = df2_nonscale['belief_diff_mobility']

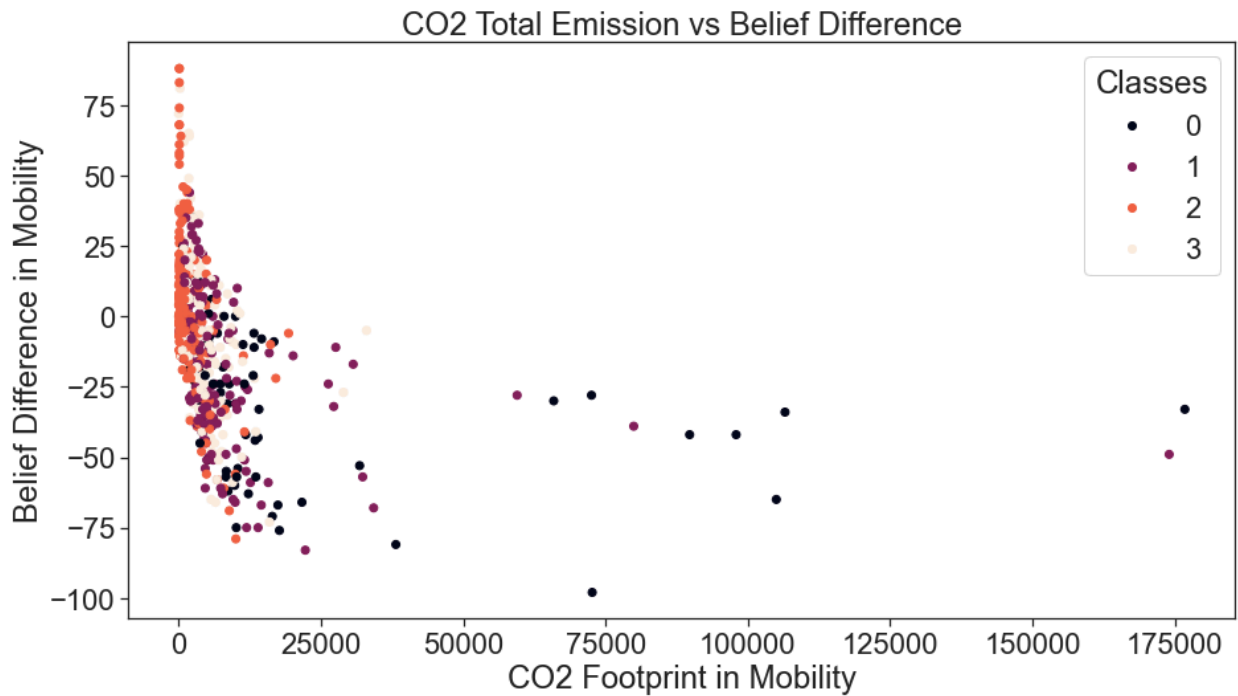
fig, ax = plt.subplots(figsize = (15, 8))

scatter = ax.scatter(x, y, c=df2_nonscale['cluster_id'])
legend1 = ax.legend(*scatter.legend_elements(),
                    loc="upper right", title="Classes")

plt.title('CO2 Total Emission vs Belief Difference')
```

```
plt.xlabel('CO2 Footprint in Mobility')
plt.ylabel('Belief Difference in Mobility')

plt.show()
```



```
In [25]: df2_nonscale.groupby(['cluster_id']).mean().round(2)
```

```
Out[25]:
```

	age	income	no_cars	CO2_cruise	CO2_flight	CO2_public_transport	CO2_car_total	CO2_n
cluster_id								
0	33.62	3493.75	1.17	9705.19	5511.72	84.22	5392.00	2
1	33.10	3820.98	1.37	0.00	2965.06	107.80	4319.52	
2	32.98	2294.13	0.16	0.00	1674.79	105.68	53.55	
3	42.17	3469.17	1.47	0.00	1296.59	0.00	3501.75	

```
In [26]: df2_nonscale.mean().round(2)
```

C:\Users\leajo\AppData\Local\Temp\ipykernel\_20380\3835566406.py:1: FutureWarning:

Dropping of nuisance columns in DataFrame reductions (with 'numeric\_only=None') is deprecated; in a future version this will raise TypeError. Select only valid columns before calling the reduction.

```
Out[26]: age                35.35
income            3171.48
no_cars           0.96
CO2_cruise       1056.35
CO2_flight       2385.35
CO2_public_transport  77.92
CO2_car_total    2761.82
CO2_mobility     6281.43
belief_diff_mobility -8.87
cluster_id       1.73
dtype: float64
```

```
In [27]: df2_nonscale.groupby(['cluster_id'])['RLK2022'].agg(pd.Series.mode)
```

```
Out[27]: cluster_id
0      sehr zentral
1      sehr zentral
2      sehr zentral
3           zentral
Name: RLK2022, dtype: object
```

```
In [28]: df2_nonscale['RLK2022'].agg(pd.Series.mode)
```

```
Out[28]: 0      sehr zentral
Name: RLK2022, dtype: object
```

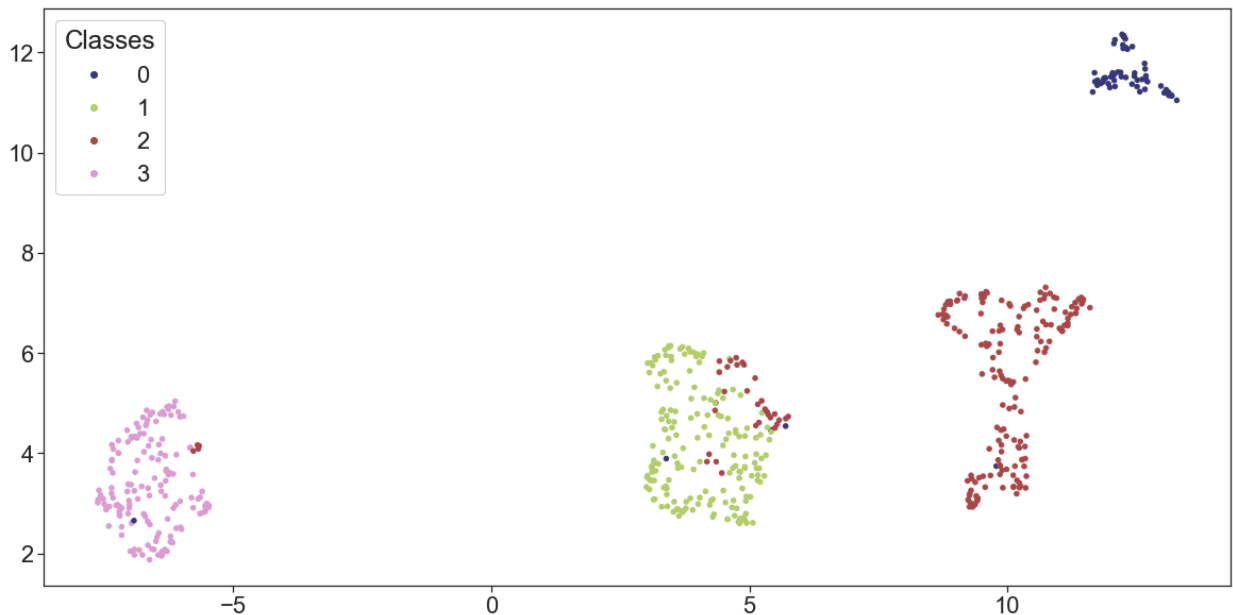
```
In [29]: df2_nonscale.to_csv('cluster_results.csv')
```

## Plotting Clusters on UMAP plot

```
In [30]: fig, ax = plt.subplots()
fig.set_size_inches((20, 10))
scatter = ax.scatter(embedding[0][:, 0], embedding[0][:, 1], s=20, c=clusters, cmap='t

# produce a legend with the unique colors from the scatter
legend1 = ax.legend(*scatter.legend_elements(num=3), loc="upper left", title="Classes")
ax.add_artist(legend1)
```

```
Out[30]: <matplotlib.legend.Legend at 0x1e3e948c400>
```



## Evaluation of the model

```
In [31]: #Setting the objects to category
lgbm_data = kprot_data.copy()
proto_clusters = pd.Series(clusters)

for c in lgbm_data.select_dtypes(include='object'):
    lgbm_data[c] = lgbm_data[c].astype('category')
```

```
In [32]: #Kprototype clusters
clf_kp = LGBMClassifier(colsample_by_tree=0.8)
cv_scores_kp = cross_val_score(clf_kp, lgbm_data, proto_clusters, scoring='f1_weighted')
print(f'CV F1 score for K-Prototypes clusters is {np.mean(cv_scores_kp)}')
```

C:\ProgramData\Anaconda3\lib\site-packages\joblib\externals\loky\backend\context.py:150: UserWarning:

Could not find the number of physical cores for the following reason:  
found 0 physical cores < 1  
Returning the number of logical cores instead. You can silence this warning by setting LOKY\_MAX\_CPU\_COUNT to the number of cores you want to use.

File "C:\ProgramData\Anaconda3\lib\site-packages\joblib\externals\loky\backend\context.py", line 245, in \_count\_physical\_cores  
raise ValueError(









localhost:8888/nbconvert/html/Documents/SRM/master thesis/data analysis/model/kprototype all var mobility final 250524.ipynb?download=fa... 116/183

localhost:8888/nbconvert/html/Documents/SRM/master thesis/data analysis/model/kprototype all var mobility final 250524.ipynb?download=fa... 117/183

localhost:8888/nbconvert/html/Documents/SRM/master thesis/data analysis/model/kprototype all var mobility final 250524.ipynb?download=fa... 118/183









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localhost:8888/nbconvert/html/Documents/SRM/master thesis/data analysis/model/kprototype all var mobility final 250524.ipynb?download=fa... 145/183

localhost:8888/nbconvert/html/Documents/SRM/master thesis/data analysis/model/kprototype all var mobility final 250524.ipynb?download=fa... 146/183

```
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
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[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
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[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] Unknown parameter: colsample_by_tree
CV F1 score for K-Prototypes clusters is 0.9609473974240675
```

```
In [33]: # Fit the model
         clf_kp.fit(lgbm_data, proto_clusters)
```



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localhost:8888/nbconvert/html/Documents/SRM/master thesis/data analysis/model/kprototype all var mobility final 250524.ipynb?download=fa... 150/183

[illegible]

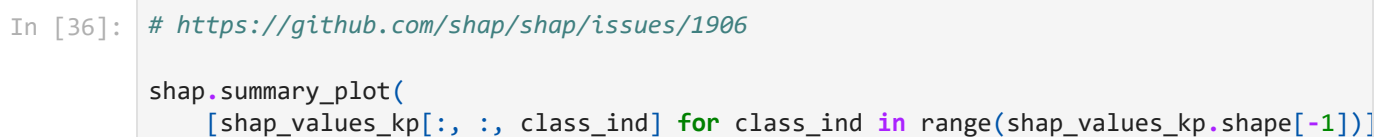
localhost:8888/nbconvert/html/Documents/SRM/master thesis/data analysis/model/kprototype all var mobility final 250524.ipynb?download=fa... 152/183



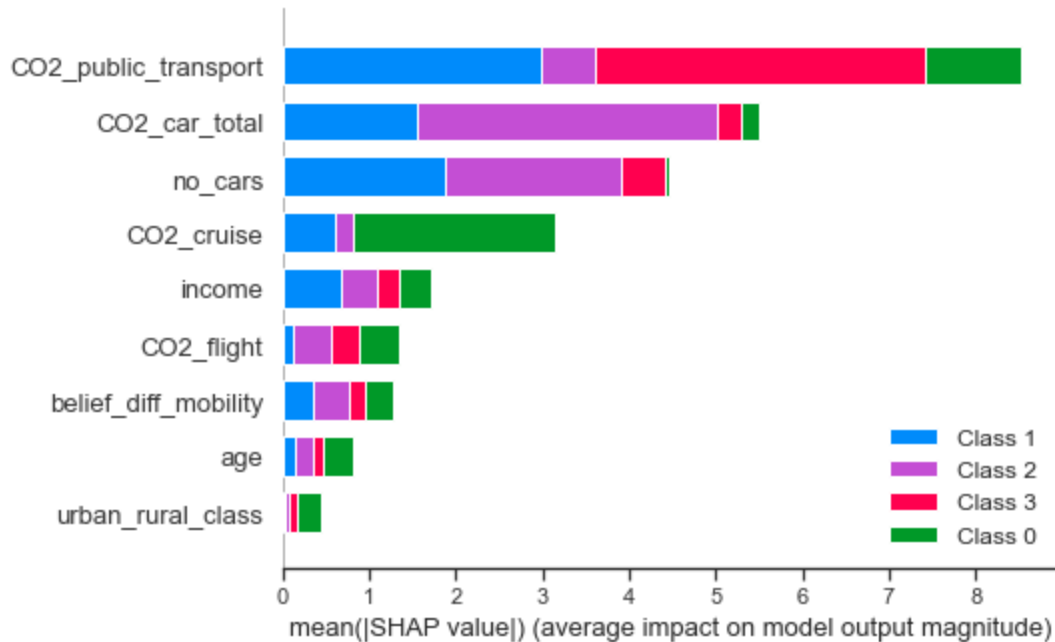
localhost:8888/nbconvert/html/Documents/SRM/master thesis/data analysis/model/kprototype all var mobility final 250524.ipynb?download=fa... 153/183

```
Out[33]: LGBMClassifier(colsample_by_tree=0.8)
```

```
In [35]: shap.summary_plot(shap_values_kp, lgbm_data, plot_type="bar", plot_size=(15, 10))
```



```
feature_names=lgbm_data.columns,
plot_type="bar"
)
```



## Analyzing the clustering results

- **variables used:** 'age','income', 'political\_party','education', 'RLK2022', 'no\_cars','CO2\_cruise', 'CO2\_flight', 'CO2\_public\_transport','CO2\_car\_total', 'CO2\_mobility','belief\_diff\_mobility'

```
In [37]: ### Change column name: 'RLK2022' will be named as urban_rural_class as it is the vari
df2_nonscale = df2_nonscale.rename(columns={'RLK2022':'urban_rural_class'})
```

```
In [128... ### or if you want to start from here, load the csv file

df2_nonscale = pd.read_csv('cluster_results.csv', header = 0)
df2_nonscale = df2_nonscale.rename(columns={'RLK2022':'urban_rural_class'})

pd.set_option('display.max_columns', None)
df2_nonscale.head(9)
```

Out[128]:

	Unnamed: 0	age	income	urban_rural_class	no_cars	CO2_cruise	CO2_flight	CO2_public_transport
0	0	65	3000.0	zentral	1.0	0.0	2440.0	0.0
1	1	59	800.0	sehr zentral	2.0	2710.0	5985.0	107.8
2	2	60	1750.0	peripher	0.0	0.0	598.5	107.8
3	3	73	2500.0	sehr zentral	1.0	0.0	2287.6	0.0
4	4	43	2500.0	sehr zentral	0.0	0.0	0.0	107.8
5	5	49	2300.0	zentral	1.0	0.0	532.0	107.8
6	6	57	600.0	zentral	1.0	0.0	0.0	0.0
7	7	39	5000.0	sehr zentral	2.0	4878.0	2074.8	107.8
8	8	62	0.0	sehr zentral	2.0	0.0	0.0	107.8

In [129...

```
# Setting the graph style
sns.set(font_scale = 2)
sns.set_style("ticks")
```

In [130...

```
df2_nonscale.head()
```

Out[130]:

	Unnamed: 0	age	income	urban_rural_class	no_cars	CO2_cruise	CO2_flight	CO2_public_transport
0	0	65	3000.0	zentral	1.0	0.0	2440.0	0.0
1	1	59	800.0	sehr zentral	2.0	2710.0	5985.0	107.8
2	2	60	1750.0	peripher	0.0	0.0	598.5	107.8
3	3	73	2500.0	sehr zentral	1.0	0.0	2287.6	0.0
4	4	43	2500.0	sehr zentral	0.0	0.0	0.0	107.8

In [131...

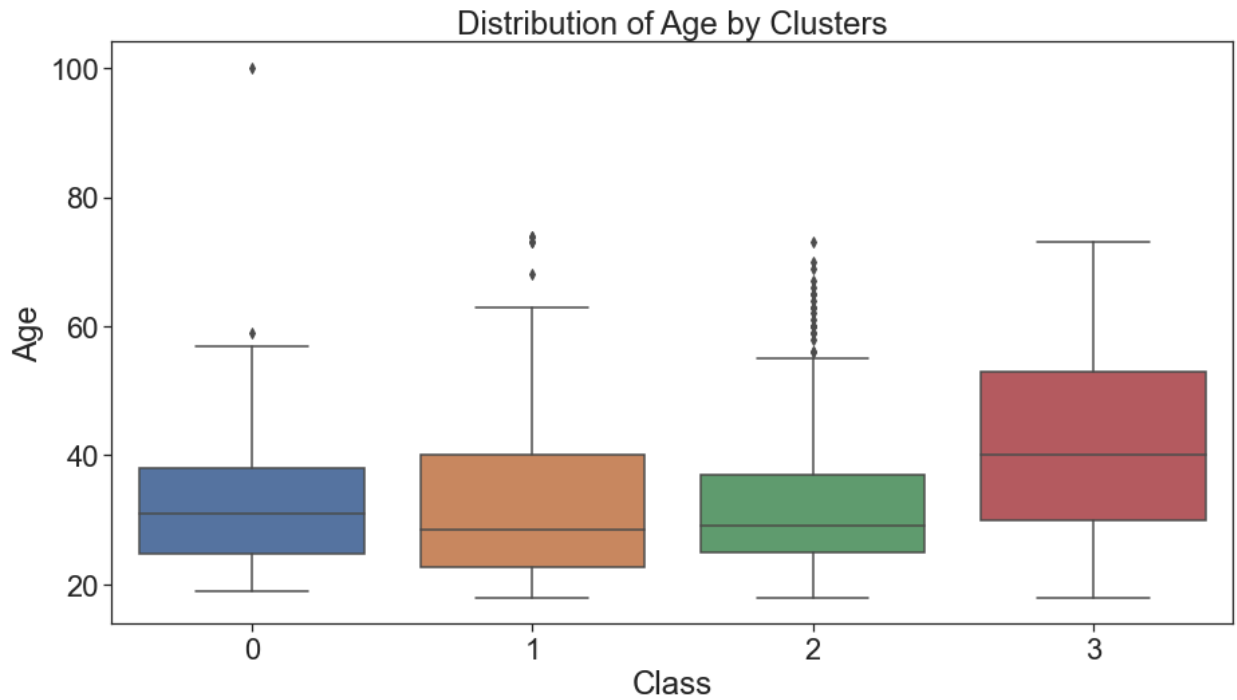
```
sns.set_style("ticks")

x_order = [0, 1, 2, 3]

fig = plt.figure(figsize=(15, 8))
ax = fig.add_subplot(111)

lines = sns.boxplot(x=df2_nonscale['cluster_id'], y=df2_nonscale['age'], order = x_order)
plt.title('Distribution of Age by Clusters')

plt.show()
```

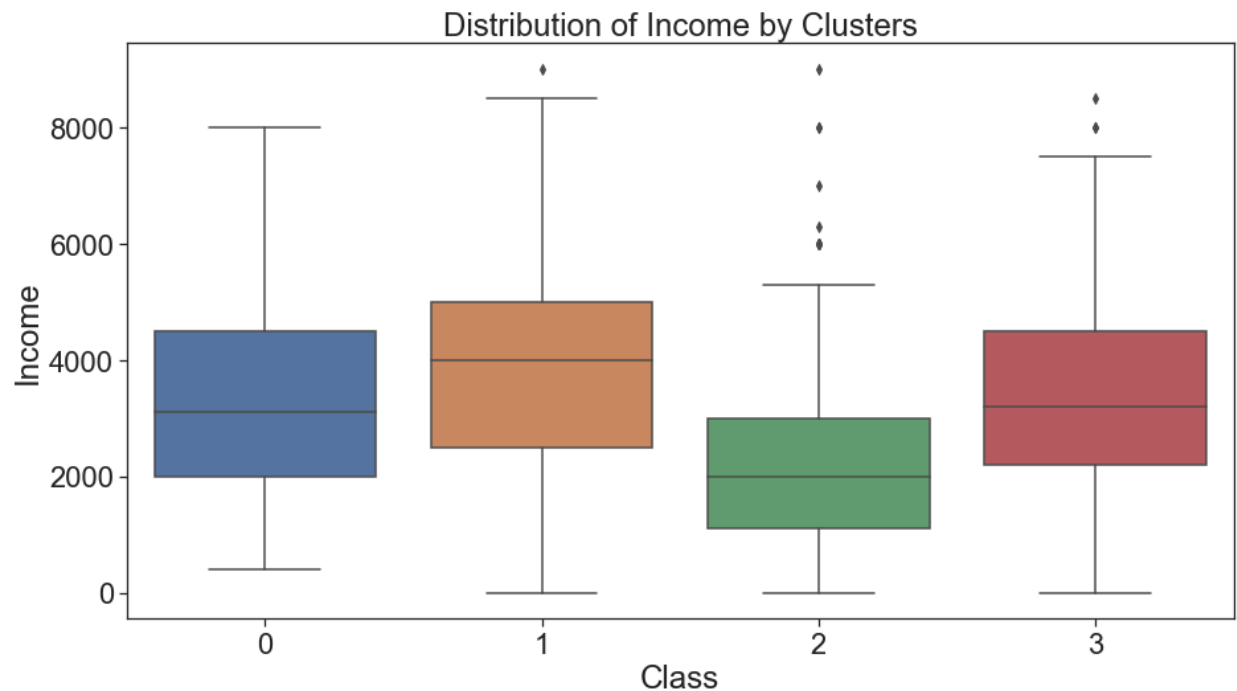


```
In [132... sns.set_style("ticks")
x_order = [0, 1, 2, 3]

fig = plt.figure(figsize=(15, 8))
ax = fig.add_subplot(111)

lines = sns.boxplot(x=df2_nonscale['cluster_id'], y=df2_nonscale['income'], order = x_order)
plt.title('Distribution of Income by Clusters')

plt.show()
```

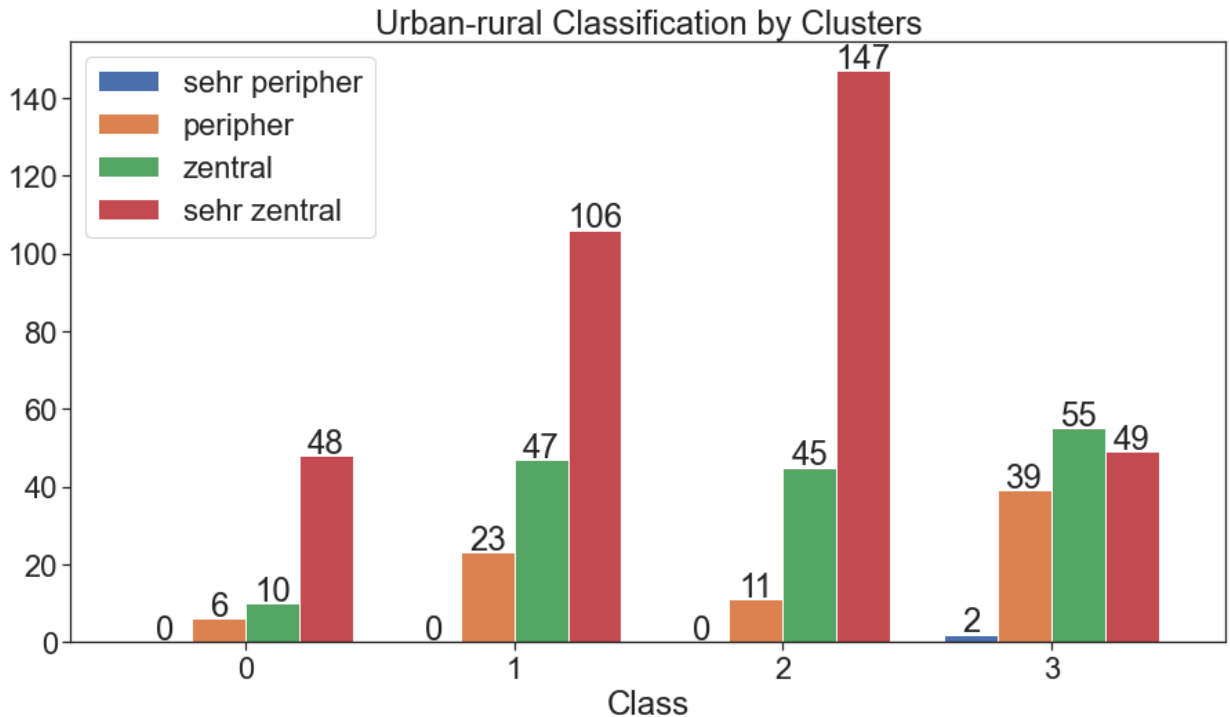


In [133...

```
sns.set_style("ticks")

ax2 = df2_nonscale.groupby(['cluster_id', 'urban_rural_class']).size().unstack(level=1)
ax2.legend(loc='upper left')
ax2.tick_params(axis='x', rotation=0)

for p in ax2.patches:
    ax2.annotate(round(p.get_height()),
                  xy=(p.get_x()+p.get_width()/2., p.get_height()+ 3),
                  ha='center',
                  va='center')
```



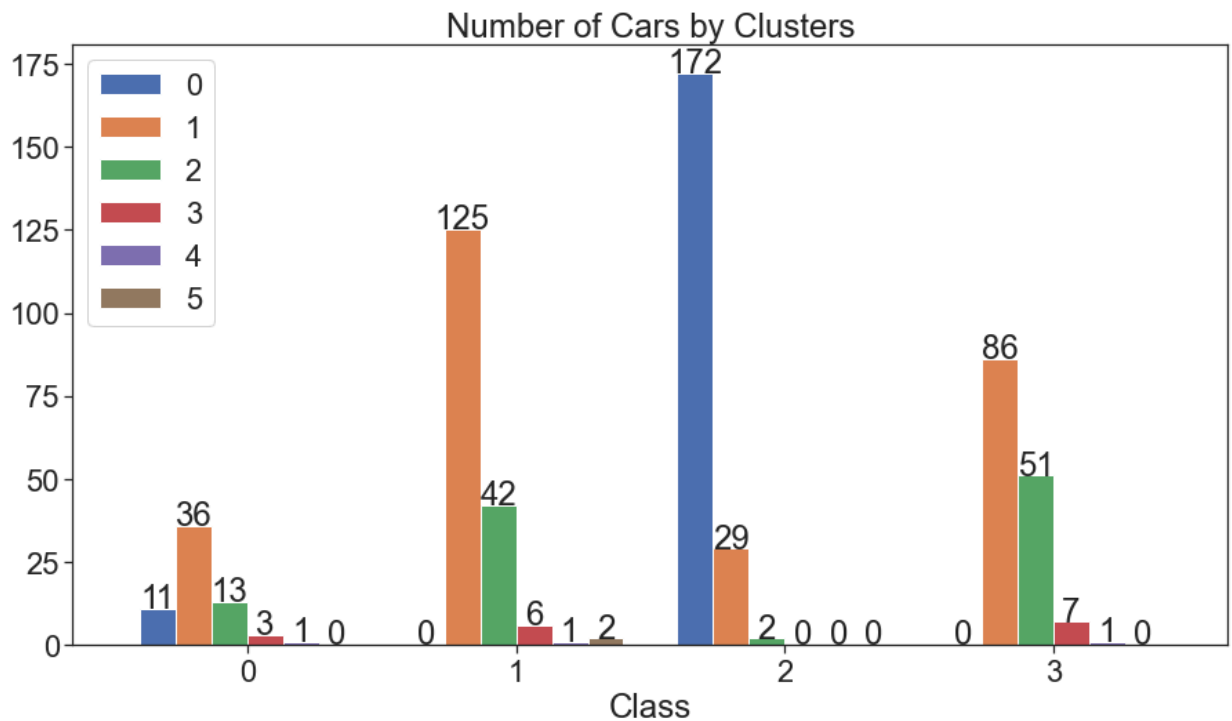
In [134...

```
sns.set_style("ticks")

df2_nonscale['no_cars'] = df2_nonscale['no_cars'].astype('int').astype('object')

ax2 = df2_nonscale.groupby(['cluster_id', 'no_cars']).size().unstack(level=1).plot(kind='bar')
ax2.legend(loc='upper left')
ax2.tick_params(axis='x', rotation=0)

for p in ax2.patches:
    ax2.annotate(round(p.get_height()),
                  xy=(p.get_x()+p.get_width()/2., p.get_height()+ 3),
                  ha='center',
                  va='center')
```



```
In [135...] round(172/(172+29+2),2)
```

```
Out[135]: 0.85
```

```
In [136...] def dist_continuous(variable):
    sns.set_style("ticks")

    x = df2_nonscale['cluster_id']
    y = df2_nonscale[variable]

    name_var_list = variable.split("_")
    name_var_list_new = []
    for i in name_var_list:
        if i != 'CO2':
            name_var_list_new.append(i.capitalize())
        else: name_var_list_new.append(i)

    name_var = ' '.join(map(str, name_var_list_new))

    x_order = [0, 1, 2, 3]

    fig = plt.figure(figsize=(15, 8))
    ax = fig.add_subplot(111)

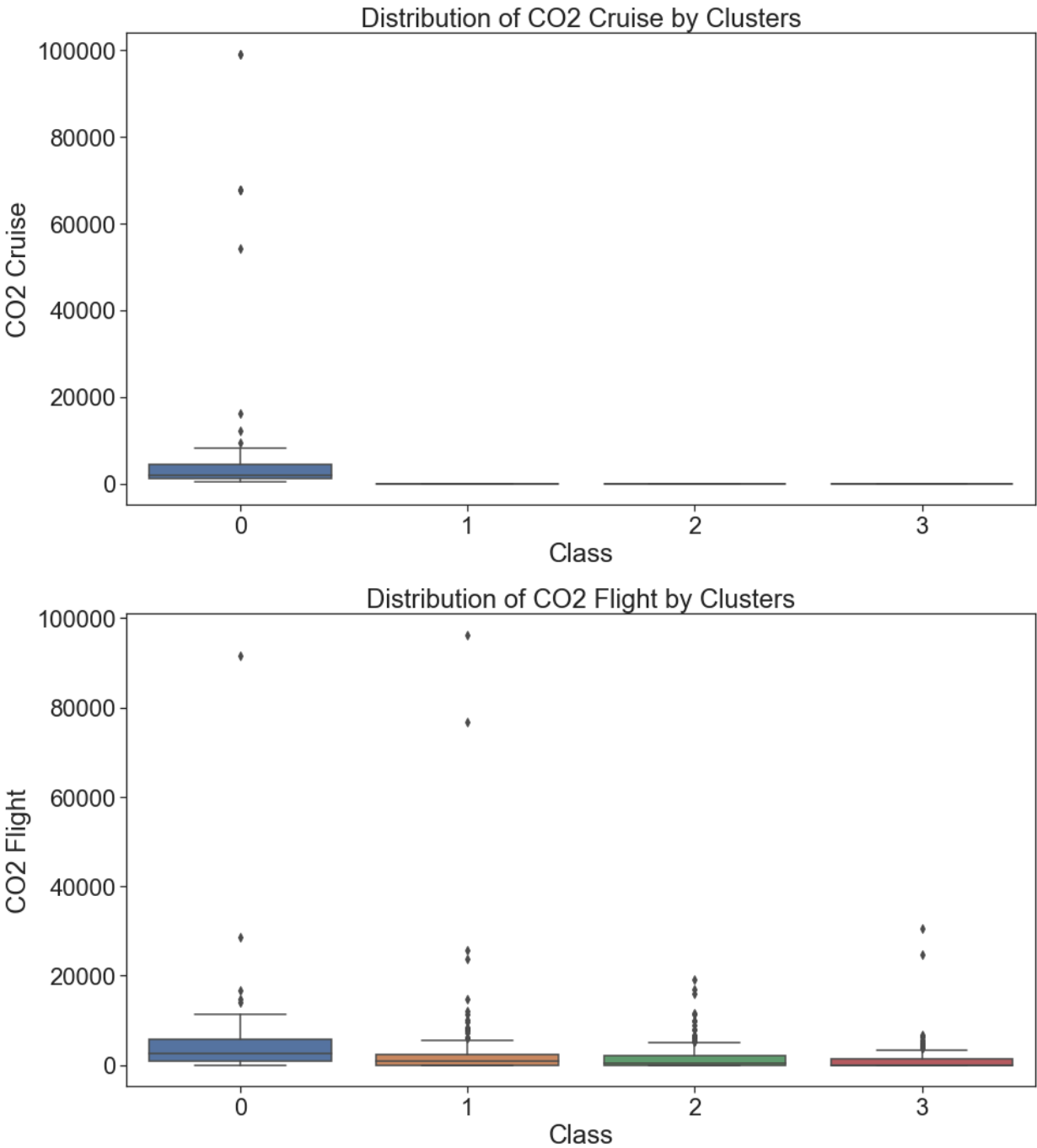
    sns.set(font_scale = 2)

    lines = sns.boxplot(x=df2_nonscale['cluster_id'], y=df2_nonscale[variable], order

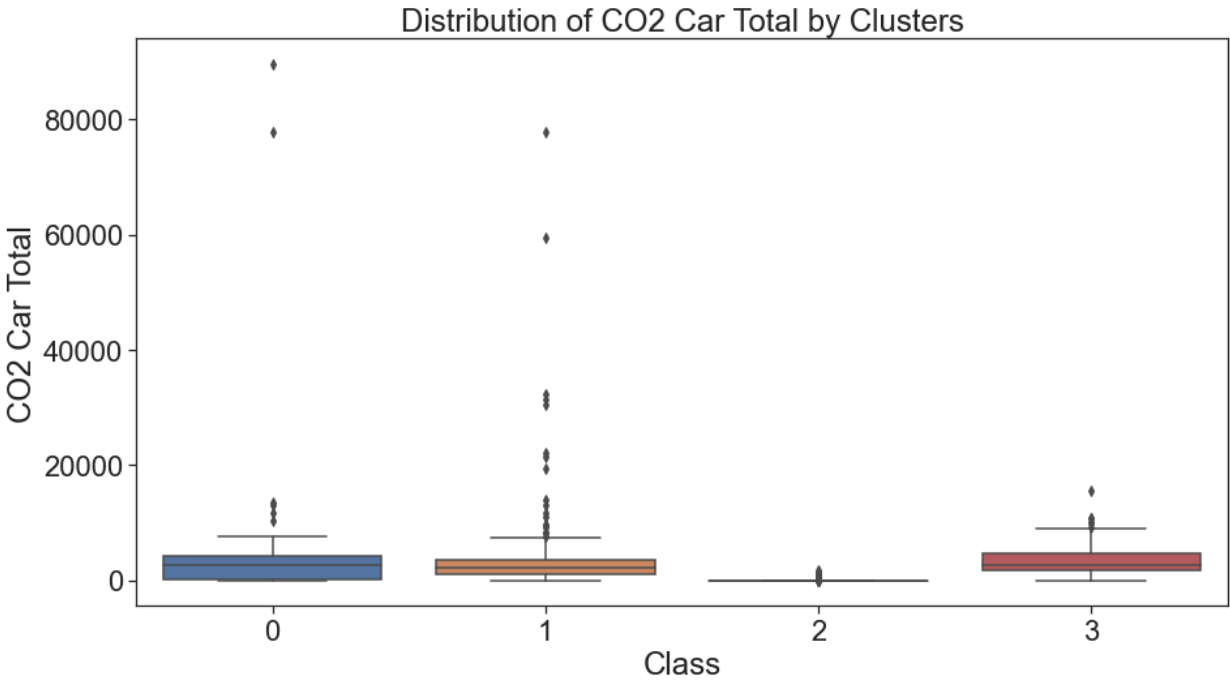
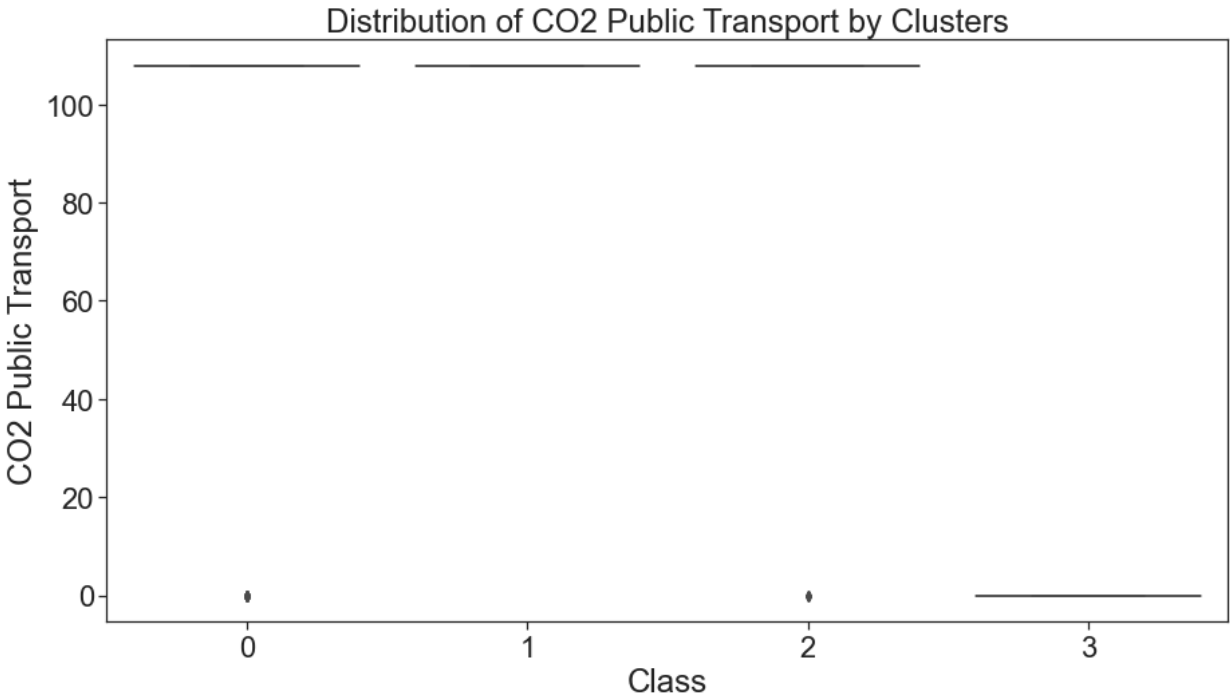
    plt.title('Distribution of ' + name_var + ' by Clusters')
    plt.show()
```

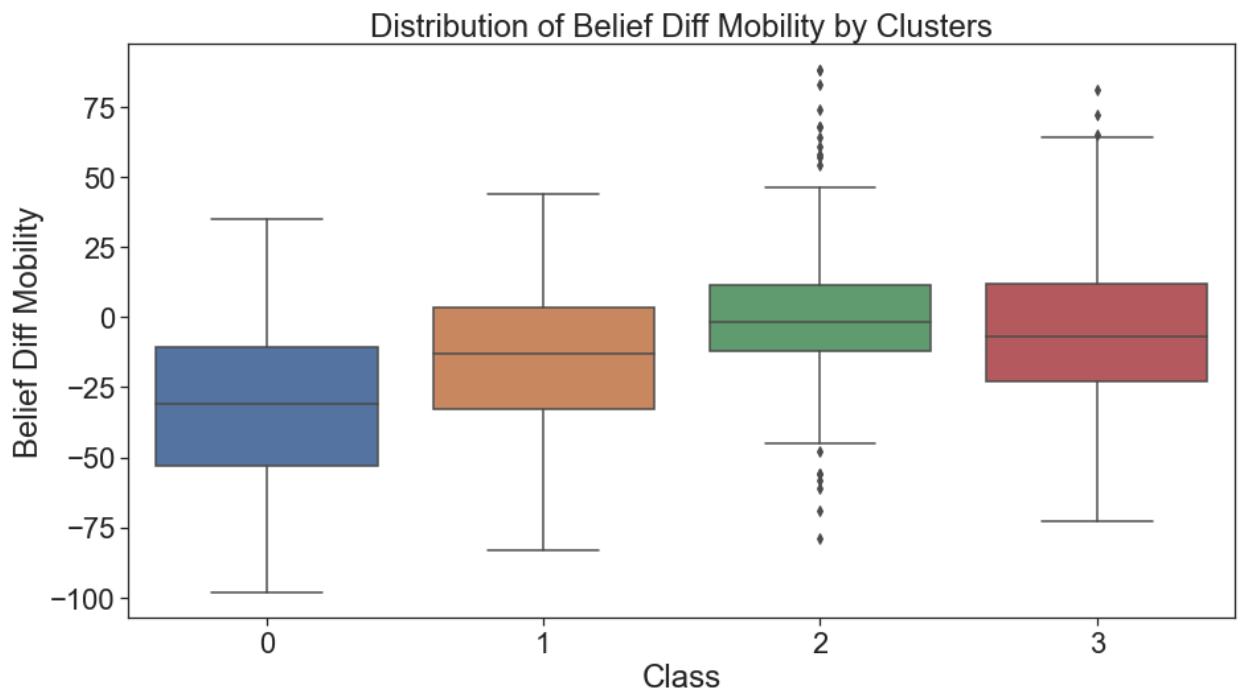
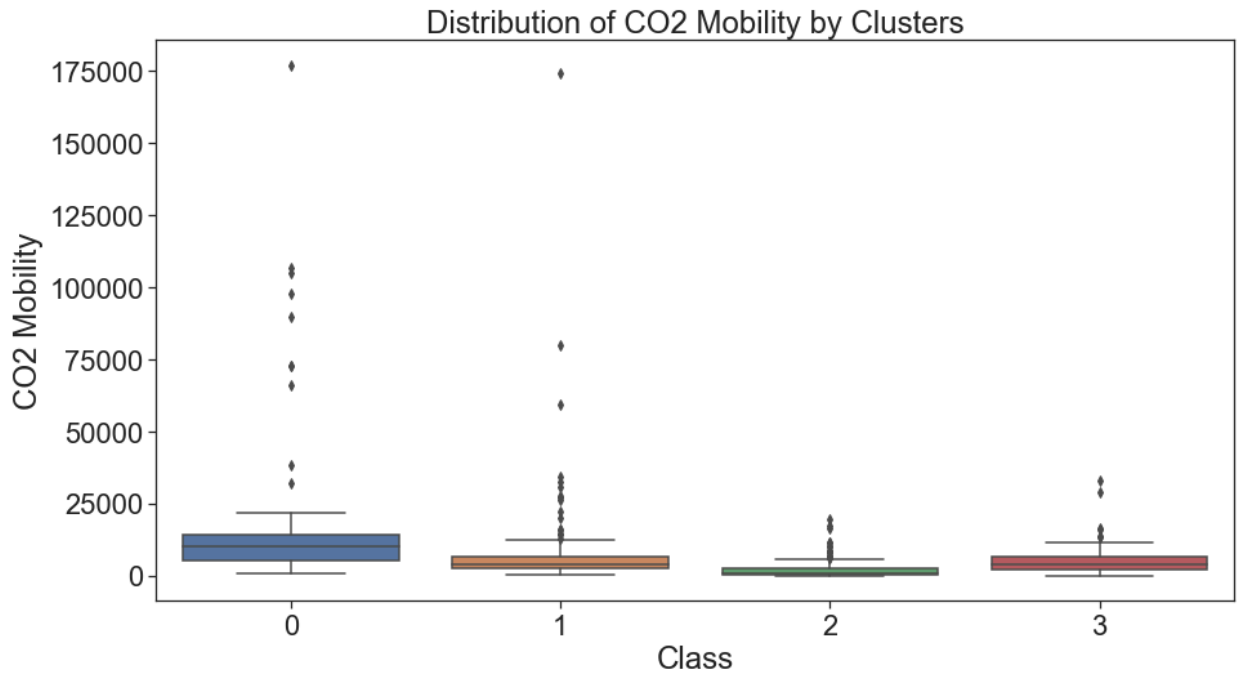
```
In [137...] variables_list = ['CO2_cruise', 'CO2_flight', 'CO2_public_transport',
    'CO2_car_total', 'CO2_mobility', 'belief_diff_mobility']
```

```
for variable in variables_list:
    dist_continuous(variable)
```









## Extra analysis to compare the clusters

```
In [138... # Creating a column for underestimation flag - 1: if underestimagte
df2_nonscale['underestimates'] = np.where(df2_nonscale['belief_diff_mobility'] < 0, 1,
```

```
In [139... # percentage of the people who are underestimating

round(100*df2_nonscale.groupby(['cluster_id'])['underestimates'].sum()/df2_nonscale.gr
```

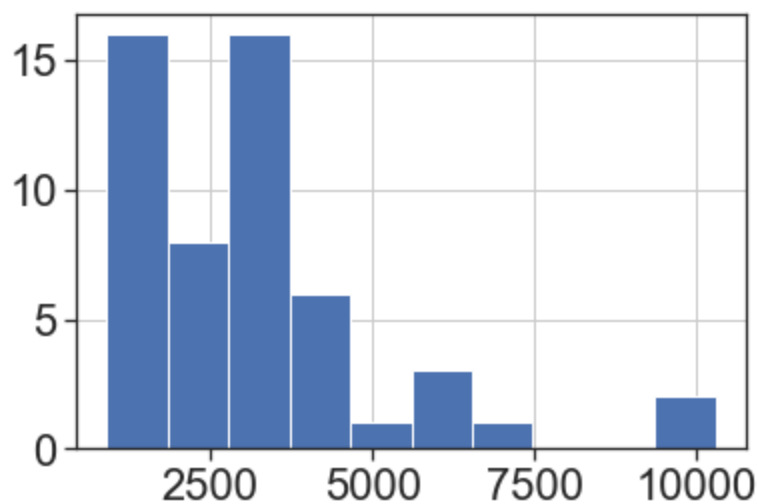
```
Out[139]: cluster_id
0      89.0
1      70.0
2      53.0
3      61.0
Name: underestimates, dtype: float64
```

```
In [140... df2_nonscale.columns
```

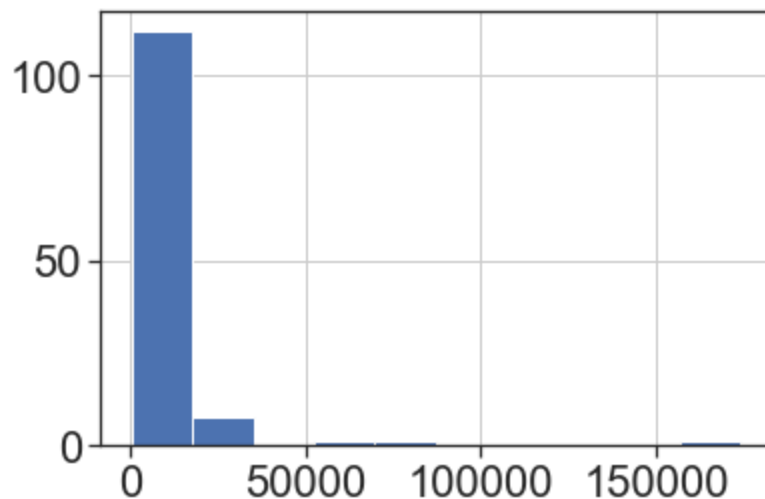
```
Out[140]: Index(['Unnamed: 0', 'age', 'income', 'urban_rural_class', 'no_cars',
      'CO2_cruise', 'CO2_flight', 'CO2_public_transport', 'CO2_car_total',
      'CO2_mobility', 'belief_diff_mobility', 'cluster_id', 'underestimates'],
      dtype='object')
```

```
In [141... sns.set_style("ticks")
```

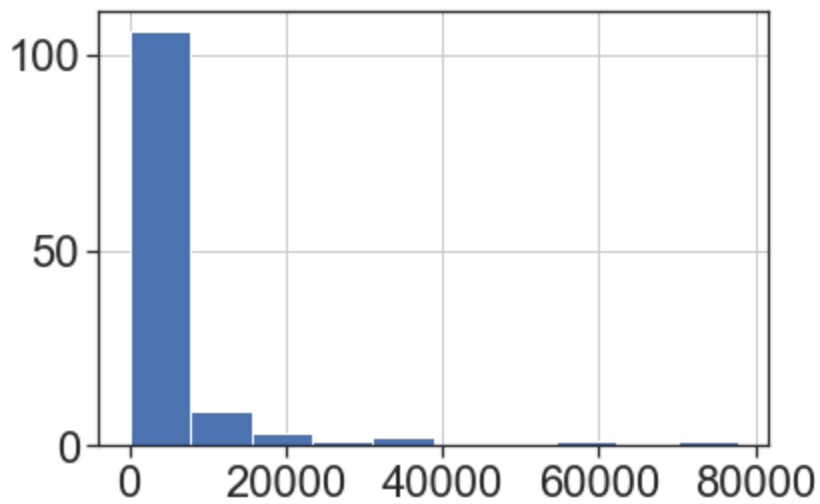
```
df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 1) & (df2_nonscale['underestimates'] > 5000)]
df2_mob['CO2_mobility'].hist();
```



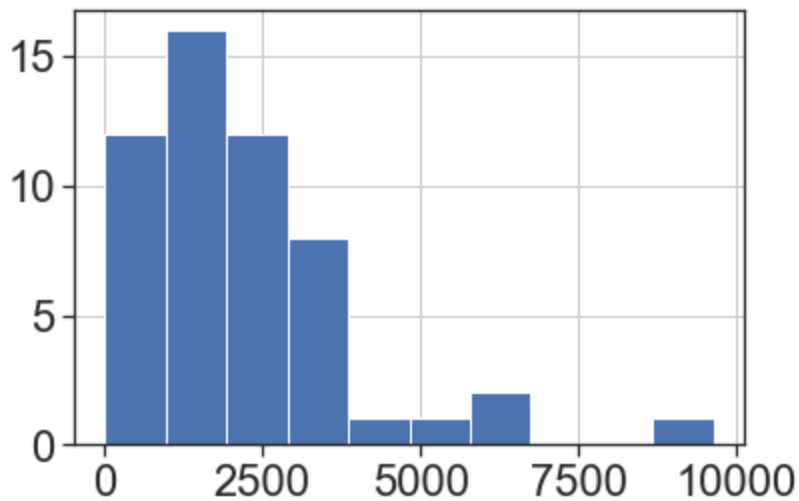
```
In [142... df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 1) & (df2_nonscale['underestimates'] > 5000)]
df2_mob['CO2_car_total'].hist();
```



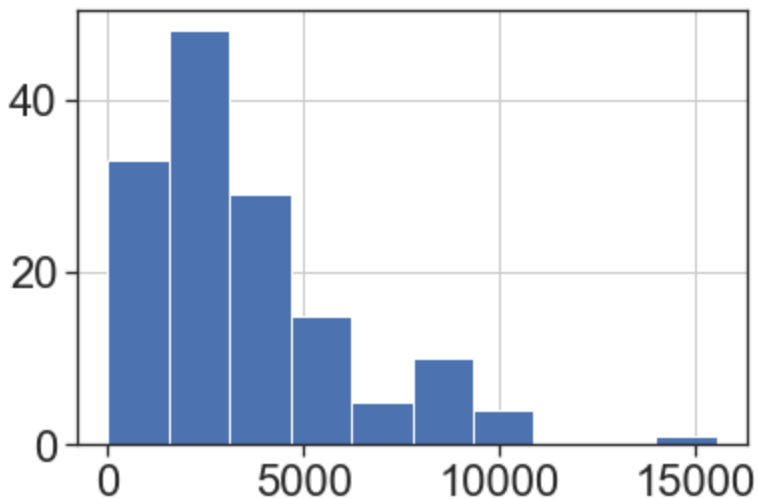
```
In [143... df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 1) & (df2_nonscale['underestimates'] > 5000)]
df2_mob['CO2_car_total'].hist();
```



```
In [144... df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 1) & (df2_nonscale['underestimat  
df2_mob['CO2_car_total'].hist();
```

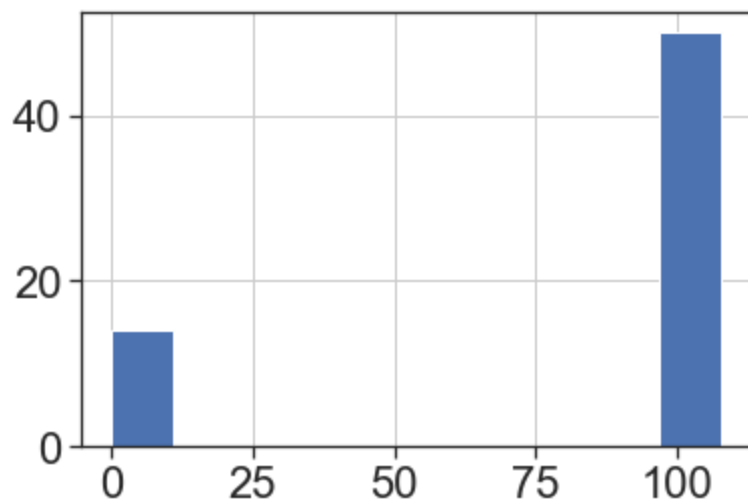


```
In [145... df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 3)]  
df2_mob['CO2_car_total'].hist();
```



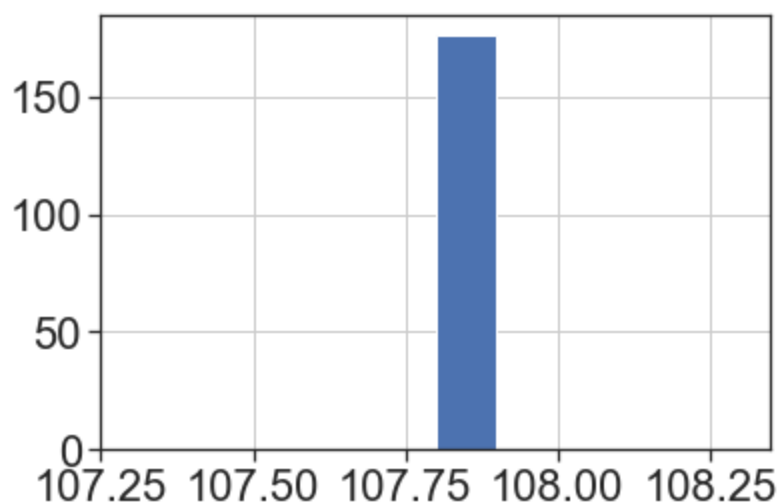
In [146...

```
## Public transportation patterns in Class 0  
df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 0)]  
df2_mob['CO2_public_transport'].hist();
```



In [147...

```
## Public transportation patterns in Class 1  
df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 1)]  
df2_mob['CO2_public_transport'].hist();
```



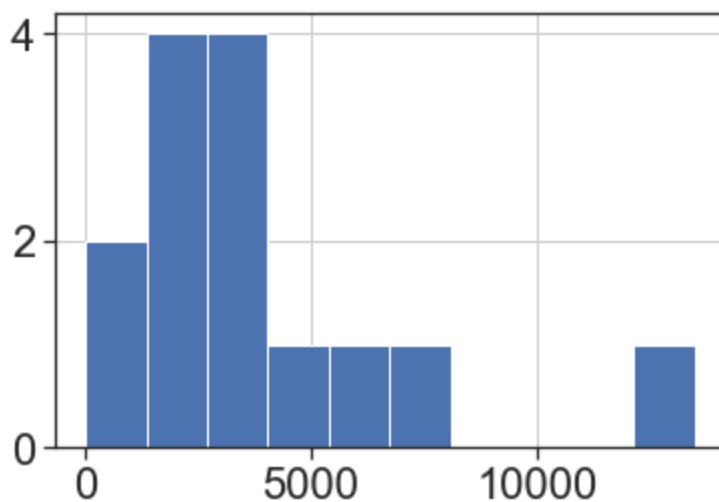
In [148...

```
# percentage of people not using public transportation in Class 0  
len(df2_nonscale[(df2_nonscale['cluster_id'] == 0) & (df2_nonscale['CO2_public_transport'] > 100)]) / len(df2_nonscale[df2_nonscale['cluster_id'] == 0])
```

Out[148]: 0.21875

In [149...

```
## Driving patterns of people not using public transportation in Class 0  
df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 0) & (df2_nonscale['CO2_public_transport'] > 100)]  
df2_mob['CO2_car_total'].hist();
```

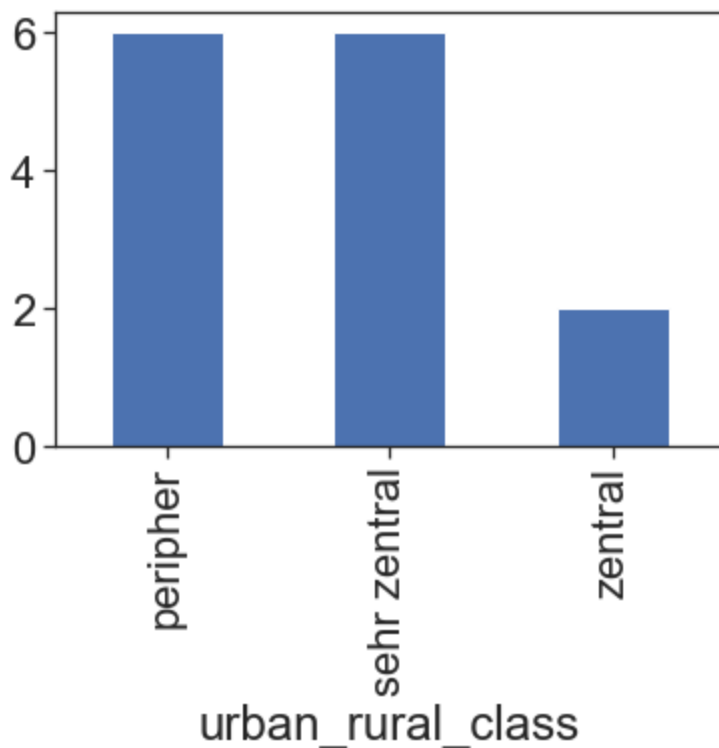


```
In [150... ## Urban-rural area of people not using public transporation in Class 0

df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 0) & (df2_nonscale['CO2_public_t

df2_mob.groupby(['urban_rural_class'])['urban_rural_class'].count().plot(kind='bar')
```

```
Out[150]: <AxesSubplot:xlabel='urban_rural_class'>
```

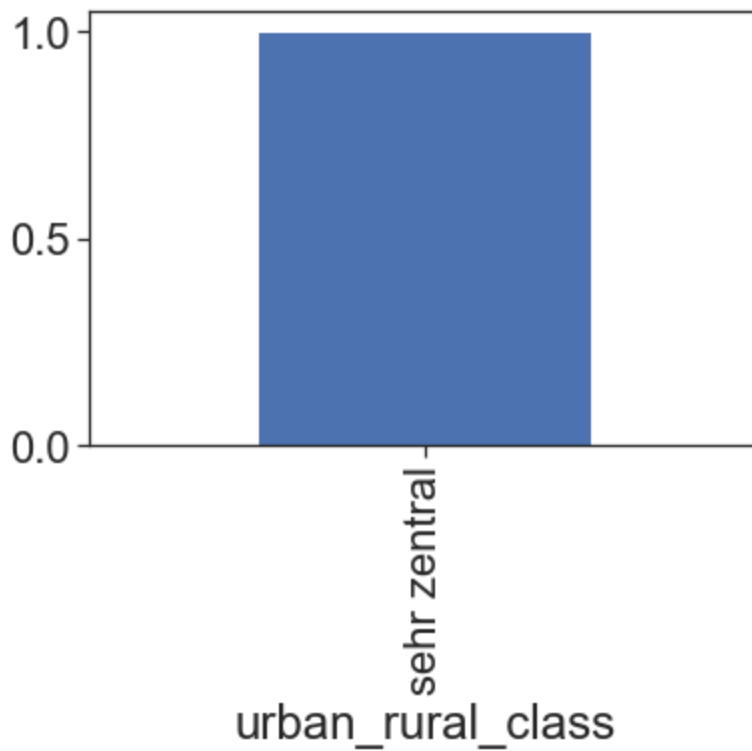


```
In [151... ## Urban-rural area of people not using public transporation nor car in Class 0

df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 0) & (df2_nonscale['CO2_public_t

df2_mob.groupby(['urban_rural_class'])['urban_rural_class'].count().plot(kind='bar')
```

```
Out[151]: <AxesSubplot:xlabel='urban_rural_class'>
```

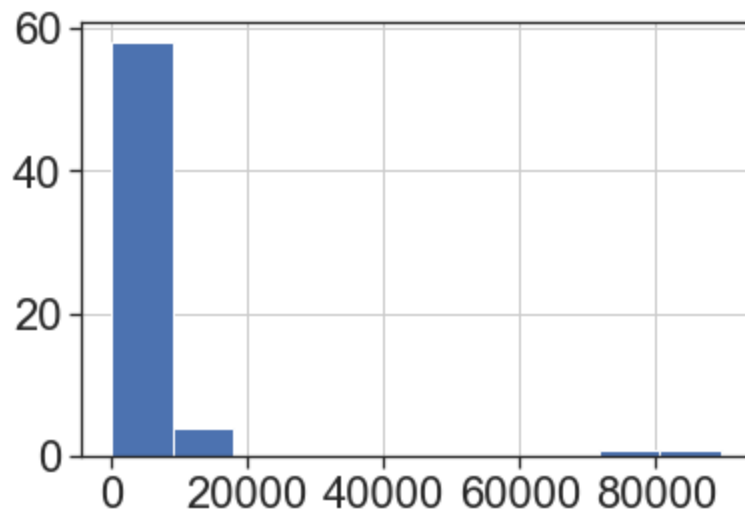


In [152...

```
## Driving patterns in Class 0
```

```
df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 0)]
```

```
df2_mob['CO2_car_total'].hist();
```

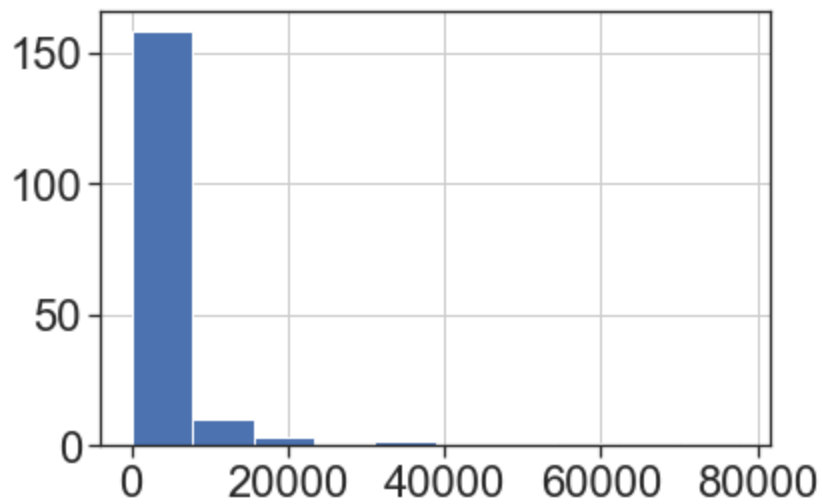


In [153...

```
## Driving patterns in Class 1
```

```
df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 1)]
```

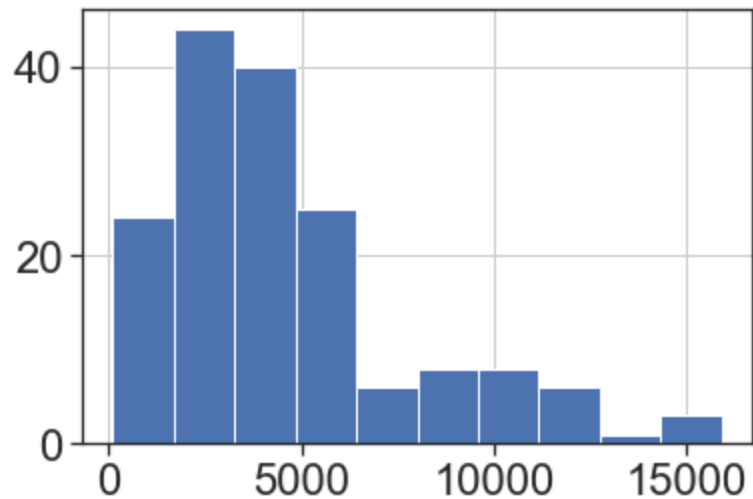
```
df2_mob['CO2_car_total'].hist();
```



In [154...

```
## investigating the outliers in Class 1
```

```
df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 1) & (df2_nonscale['CO2_mobility'] > 40000)]  
df2_mob['CO2_mobility'].hist();
```

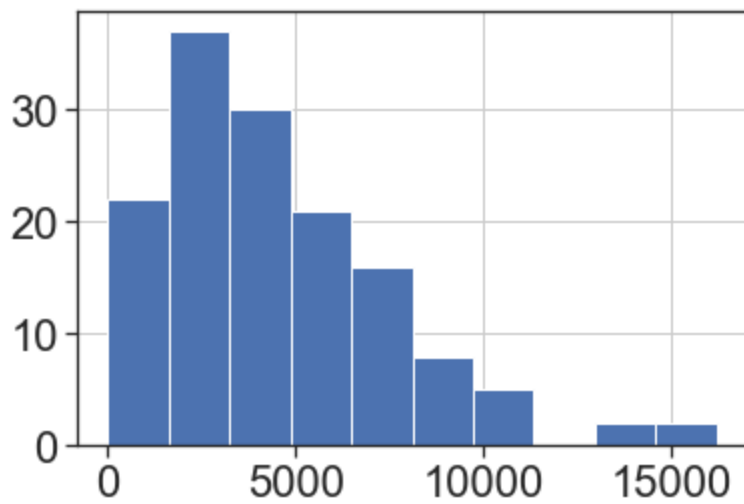


In [155...

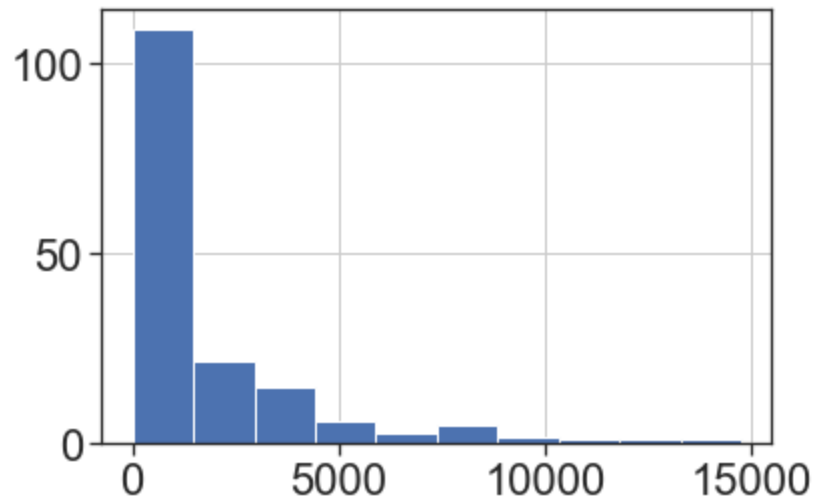
```
## investigating the outliers in Class 3
```

```
df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 3) & (df2_nonscale['CO2_mobility'] > 10000)]  
df2_mob['CO2_mobility'].hist();
```

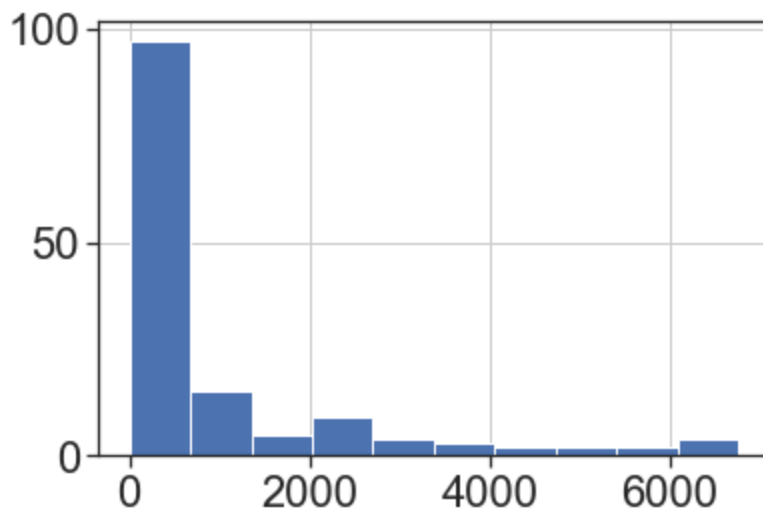




```
In [156... ## investigating the outliers in Class 1  
  
df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 1) & (df2_nonscale['CO2_mobility'  
df2_mob['CO2_flight'].hist();
```

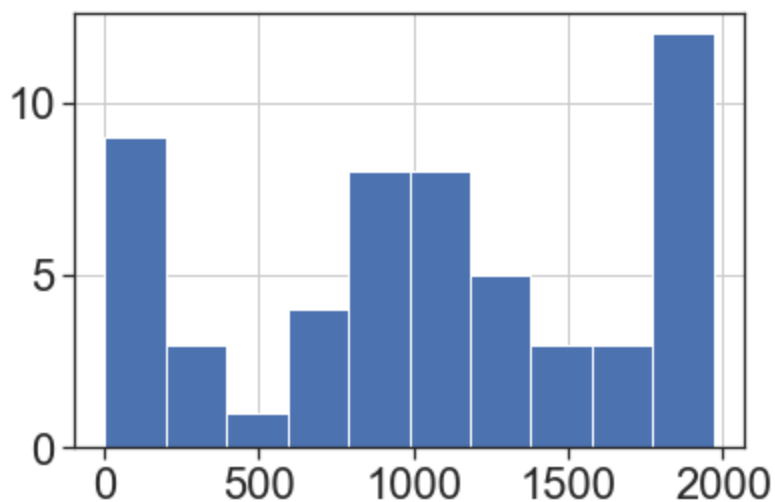


```
In [157... ## investigating the outliers in Class 3  
  
df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 3) & (df2_nonscale['CO2_mobility'  
df2_mob['CO2_flight'].hist();
```



```
In [158... ## investigating the outliers in Class 1

df2_mob = df2_nonscale[(df2_nonscale['cluster_id'] == 1) & (df2_nonscale['urban_rural_
df2_mob['CO2_car_total'].hist();
```



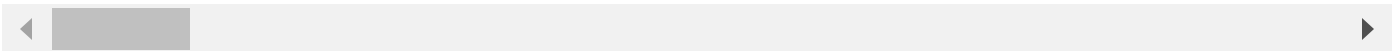
```
In [159... ### Comparing the engine

engine = pd.read_csv('data_cleaned_descriptive_analysis_final_batch_engine.csv', head=
engine = engine.rename(columns={'RLK2022': 'urban_rural_class'})

pd.set_option('display.max_columns', None)
engine.head(9)
```

Out[159]:

	Unnamed: 0	no_cars	gender	age	income	political_party	education	postal_code	EURO5
0	25	1.0	Weiblich	65	3000.0	CDU/CSU	(Fach-) Hochschulabschluss (Bachelor, Master, ...	66440	
1	26	2.0	Weiblich	59	800.0	Keine Angabe	Allgemeine oder fachgebundene Hochschulreife/A...	65933	
2	27	0.0	Weiblich	60	1750.0	Keine Angabe	Berufsausbildung, Lehre oder Ausbildung an ein...	95028	
3	28	1.0	Männlich	73	2500.0	SPD	Realschulabschluss (Mittlere Reife) oder gleic...	63741	
4	30	0.0	Männlich	43	2500.0	Einer anderen Partei	Berufsausbildung, Lehre oder Ausbildung an ein...	13059	
5	31	1.0	Weiblich	49	2300.0	CDU/CSU	Berufsausbildung, Lehre oder Ausbildung an ein...	39112	
6	32	1.0	Weiblich	57	600.0	CDU/CSU	Realschulabschluss (Mittlere Reife) oder gleic...	78244	
7	33	2.0	Männlich	39	5000.0	SPD	(Fach-) Hochschulabschluss (Bachelor, Master, ...	10115	
8	34	2.0	Männlich	62	0.0	Keine Angabe	(Fach-) Hochschulabschluss (Bachelor, Master, ...	46149	



```
In [37]: len(engine)
```

Out[37]: 588

```
In [160... df2_nonscale.head()
```

Out[160]:

	Unnamed: 0	age	income	urban_rural_class	no_cars	CO2_cruise	CO2_flight	CO2_public_transport
0	0	65	3000.0	zentral	1	0.0	2440.0	0.0
1	1	59	800.0	sehr zentral	2	2710.0	5985.0	107.8
2	2	60	1750.0	peripher	0	0.0	598.5	107.8
3	3	73	2500.0	sehr zentral	1	0.0	2287.6	0.0
4	4	43	2500.0	sehr zentral	0	0.0	0.0	107.8

In [161]...

engine.columns

Out[161]:

```
Index(['Unnamed: 0', 'no_cars', 'gender', 'age', 'income', 'political_party',
      'education', 'postal_code', 'EUROSTAT', 'urban_rural_class', 'KTU2022',
      'federal_state', 'NUTS2_NAME', 'NUTS3_NAME', 'CO2_housing',
      'CO2_electricity', 'CO2_housing_electricity', 'CO2_cruise',
      'CO2_flight', 'CO2_public_transport', 'CO2_car1', 'CO2_car2',
      'CO2_car3', 'CO2_car4', 'CO2_car5', 'CO2_car_total', 'CO2_mobility',
      'CO2_food', 'CO2_other_consumption', 'public_emission', 'CO2_total',
      'belief_housing_electricity', 'belief_mobility', 'belief_food',
      'belief_other_consumption', 'belief_total', 'batch', 'engine_1',
      'engine_2', 'engine_3', 'engine_4', 'engine_5', 'engine_6', 'engine_7',
      'engine_8', 'engine_9', 'engine_10',
      'actual_rank_CO2_housing_electricity1', 'actual_rank_CO2_mobility1',
      'actual_rank_CO2_food1', 'actual_rank_CO2_other_consumption1',
      'actual_rank_CO2_total1', 'actual_rank_CO2_housing_electricity2',
      'actual_rank_CO2_mobility2', 'actual_rank_CO2_food2',
      'actual_rank_CO2_other_consumption2', 'actual_rank_CO2_total2',
      'belief_diff_housing_electricity', 'belief_diff_mobility',
      'belief_diff_food', 'belief_diff_other_consumption',
      'belief_diff_total'],
      dtype='object')
```

In [162]...

## Adding the engine information

```
df2_nonscale['engine_1'] = engine['engine_1']
df2_nonscale['engine_2'] = engine['engine_2']
df2_nonscale['engine_3'] = engine['engine_3']
df2_nonscale['engine_4'] = engine['engine_4']
df2_nonscale['engine_5'] = engine['engine_5']
df2_nonscale['engine_6'] = engine['engine_6']
df2_nonscale['engine_7'] = engine['engine_7']
df2_nonscale['engine_8'] = engine['engine_8']
df2_nonscale['engine_9'] = engine['engine_9']
df2_nonscale['engine_10'] = engine['engine_10']

df2_nonscale.head()
```

Out[162]:

	Unnamed: 0	age	income	urban_rural_class	no_cars	CO2_cruise	CO2_flight	CO2_public_transport
0	0	65	3000.0	zentral	1	0.0	2440.0	0.0
1	1	59	800.0	sehr zentral	2	2710.0	5985.0	107.8
2	2	60	1750.0	peripher	0	0.0	598.5	107.8
3	3	73	2500.0	sehr zentral	1	0.0	2287.6	0.0
4	4	43	2500.0	sehr zentral	0	0.0	0.0	107.8

In [163... *## All engines*

```
all_engine = engine['engine_1'].to_list() + engine['engine_3'].to_list() + engine['engine_4'].to_list()
len(all_engine)
```

Out[163]: 2940

In [164...

```
all_engine_clean = [x for x in all_engine if pd.notnull(x)]
len(all_engine_clean)

df_engine = pd.DataFrame({'col':all_engine_clean})
```

In [165... *# Bar chart for the first engine*

```
sns.set_style("ticks")

count = df_engine.groupby(['col']).size().to_frame().reset_index()

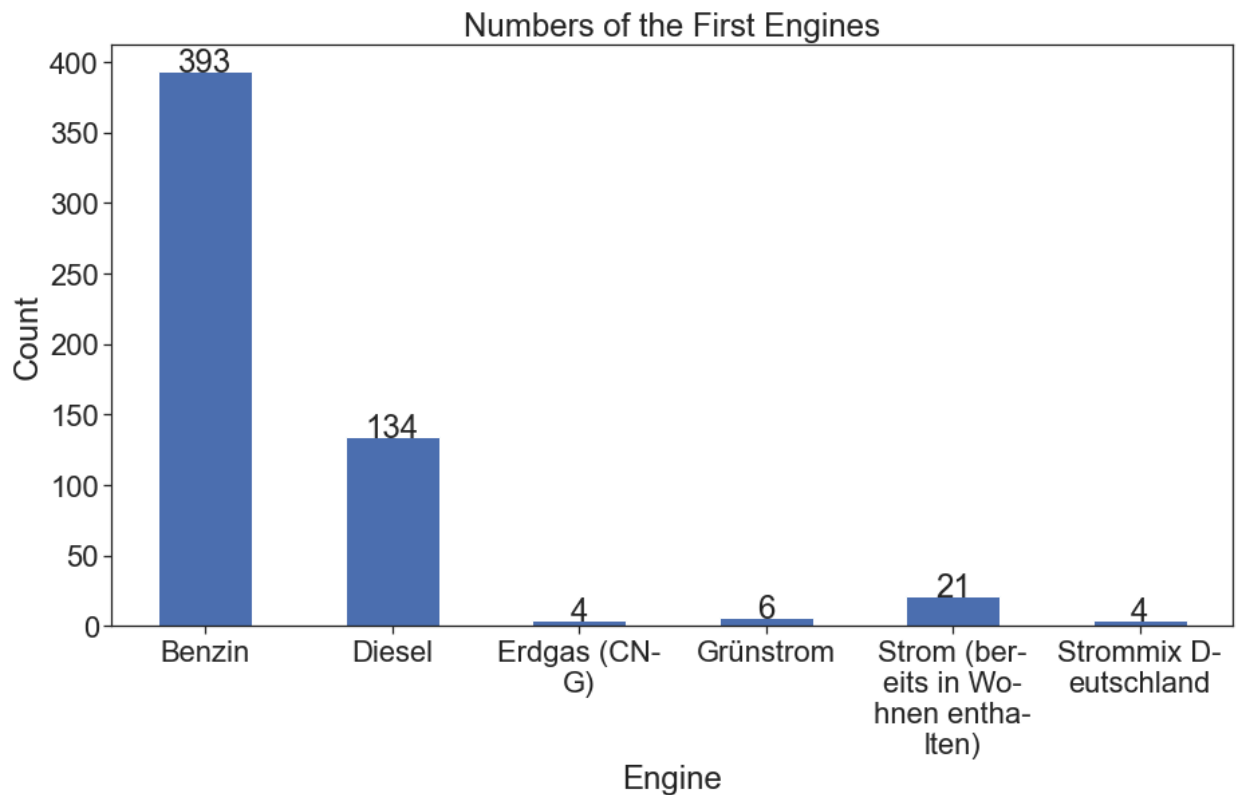
ax = count.set_index('col').plot(kind='bar', figsize=(15, 8), ylabel='Count', xlabel = 'Urban/Rural Class')
ax.get_legend().remove()

for p in ax.patches:
    ax.annotate(p.get_height(),
                xy=(p.get_x()+p.get_width()/2., p.get_height()+6),
                ha='center',
                va='center')

max_chars = 10

new_labels = ['-\\n'.join(label._text[i:i + max_chars]
                           for i in range(0, len(label._text), max_chars ))
               for label in ax.get_xticklabels()]

ax.set_xticklabels(new_labels);
```



In [166...

```
## bar chart for the second engine
```

```
all_engine2 = engine['engine_2'].to_list() + engine['engine_4'].to_list() + engine['engine_6'].to_list()
all_engine_clean2 = [x for x in all_engine2 if pd.notnull(x)]
```

```
df_engine2 = pd.DataFrame({'col':all_engine_clean2})
```

```
count = df_engine2.groupby(['col']).size().to_frame().reset_index()
```

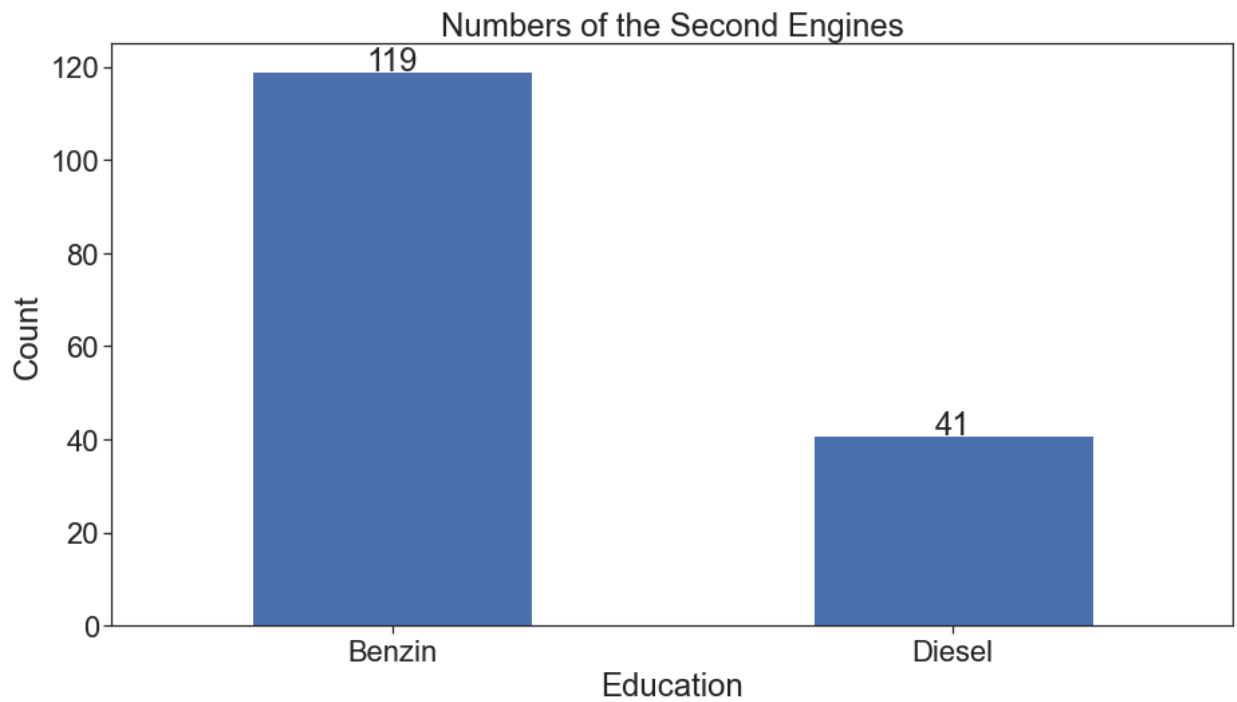
```
ax = count.set_index('col').plot(kind='bar', figsize=(15, 8), xlabel='Education', ylabel='Count')
ax.get_legend().remove()
```

```
for p in ax.patches:
    ax.annotate(p.get_height(),
                xy=(p.get_x()+p.get_width()/2., p.get_height()+2),
                ha='center',
                va='center')
```

```
max_chars = 10
```

```
new_labels = ['-\\n'.join(label._text[i:i + max_chars]
                           for i in range(0, len(label._text), max_chars))
               for label in ax.get_xticklabels()]
```

```
ax.set_xticklabels(new_labels);
```



```
In [171... ## ALL engine answered

df_engine3 = pd.concat([df_engine, df_engine2])

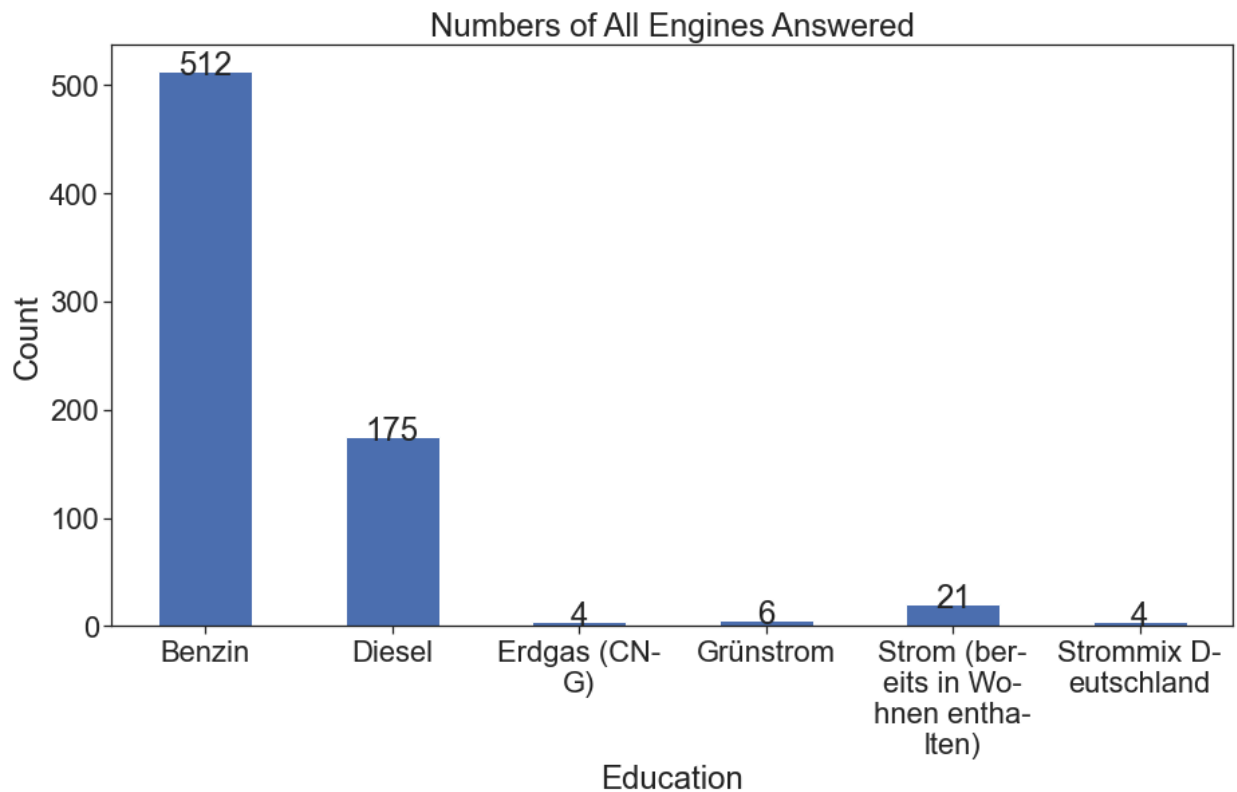
count = df_engine3.groupby(['col']).size().to_frame().reset_index()

ax = count.set_index('col').plot(kind='bar', figsize=(15, 8), xlabel='Education', ylab=
ax.get_legend().remove()

for p in ax.patches:
    ax.annotate(p.get_height(),
                xy=(p.get_x()+p.get_width()/2., p.get_height()+5),
                ha='center',
                va='center')
max_chars = 10

new_labels = ['-\\n'.join(label._text[i:i + max_chars]
                        for i in range(0, len(label._text), max_chars ))
              for label in ax.get_xticklabels()]

ax.set_xticklabels(new_labels);
```



```
In [173]: round(100*df_engine3.groupby(['col']).size()/len(df_engine3['col']), 2)
```

```
Out[173]: col
Benzin                                70.91
Diesel                                24.24
Erdgas (CNG)                          0.55
Grünstrom                             0.83
Strom (bereits in Wohnen enthalten)    2.91
Strommix Deutschland                  0.55
dtype: float64
```

```
In [174]: 0.83+2.91+0.55
```

```
Out[174]: 4.29
```

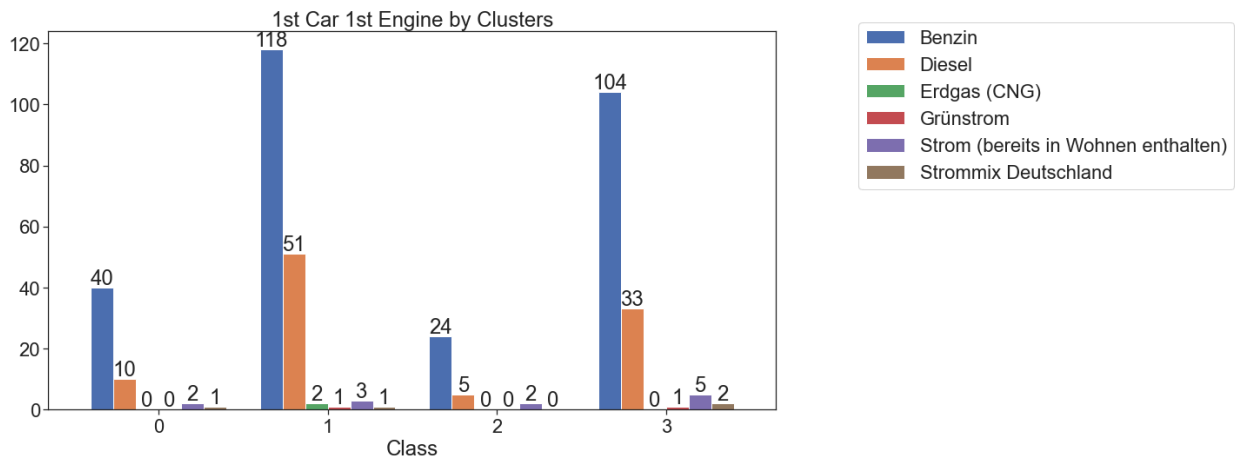
```
In [48]: sns.set_style("ticks")
```

```
#df2_nonscale['engine_1'] = df2_nonscale['no_cars'].astype('int').astype('object')

ax2 = df2_nonscale.groupby(['cluster_id', 'engine_1']).size().unstack(level=1).plot(kind='bar')
ax2.legend(bbox_to_anchor=(1.1, 1.05))
ax2.tick_params(axis='x', rotation=0)

for p in ax2.patches:
    ax2.annotate(round(p.get_height()),
                  xy=(p.get_x()+p.get_width()/2., p.get_height()+ 3),
                  ha='center',
                  va='center')
```



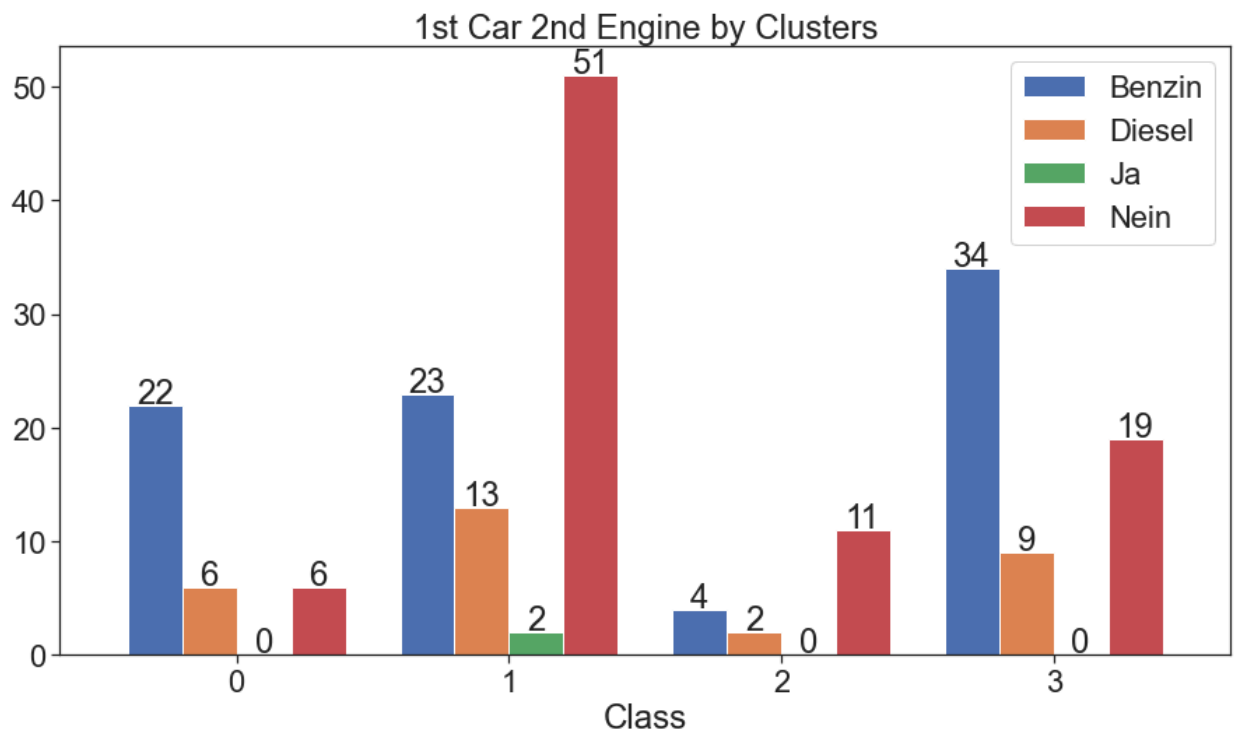


```
In [73]: sns.set_style("ticks")

#df2_nonscale['engine_1'] = df2_nonscale['no_cars'].astype('int').astype('object')

ax2 = df2_nonscale.groupby(['cluster_id', 'engine_2']).size().unstack(level=1).plot(kind='bar')
ax2.legend(bbox_to_anchor=(1, 1))
ax2.tick_params(axis='x', rotation=0)

for p in ax2.patches:
    ax2.annotate(round(p.get_height()),
                  xy=(p.get_x()+p.get_width()/2., p.get_height()+1),
                  ha='center',
                  va='center')
```



```
In [50]: sns.set_style("ticks")

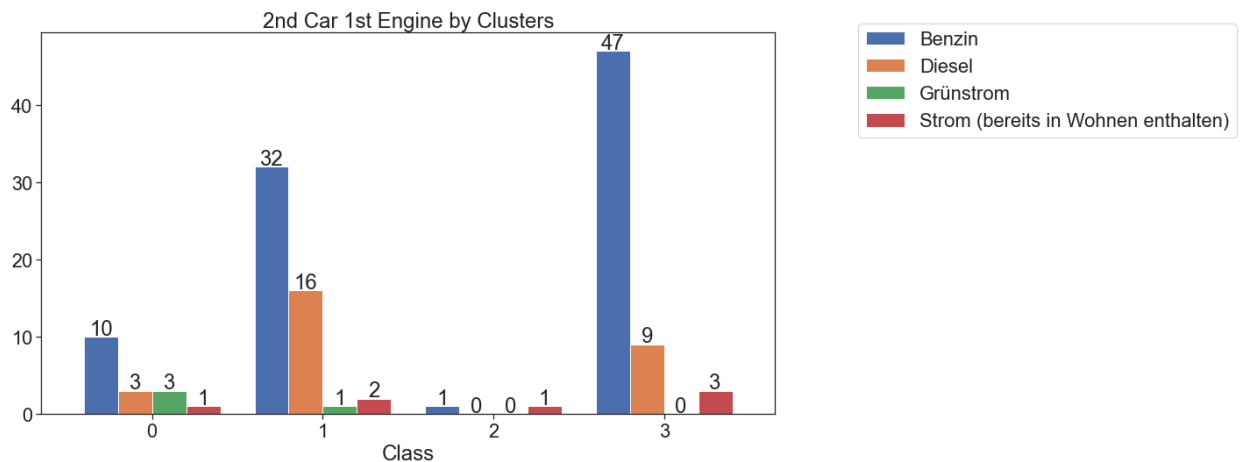
#df2_nonscale['engine_1'] = df2_nonscale['no_cars'].astype('int').astype('object')
```

```

ax2 = df2_nonscale.groupby(['cluster_id', 'engine_3']).size().unstack(level=1).plot(kind='bar')
ax2.legend(bbox_to_anchor=(1.1, 1.05))
ax2.tick_params(axis='x', rotation=0)

for p in ax2.patches:
    ax2.annotate(round(p.get_height()),
                  xy=(p.get_x()+p.get_width()/2., p.get_height()+ 1),
                  ha='center',
                  va='center')

```



```

In [77]: sns.set_style("ticks")

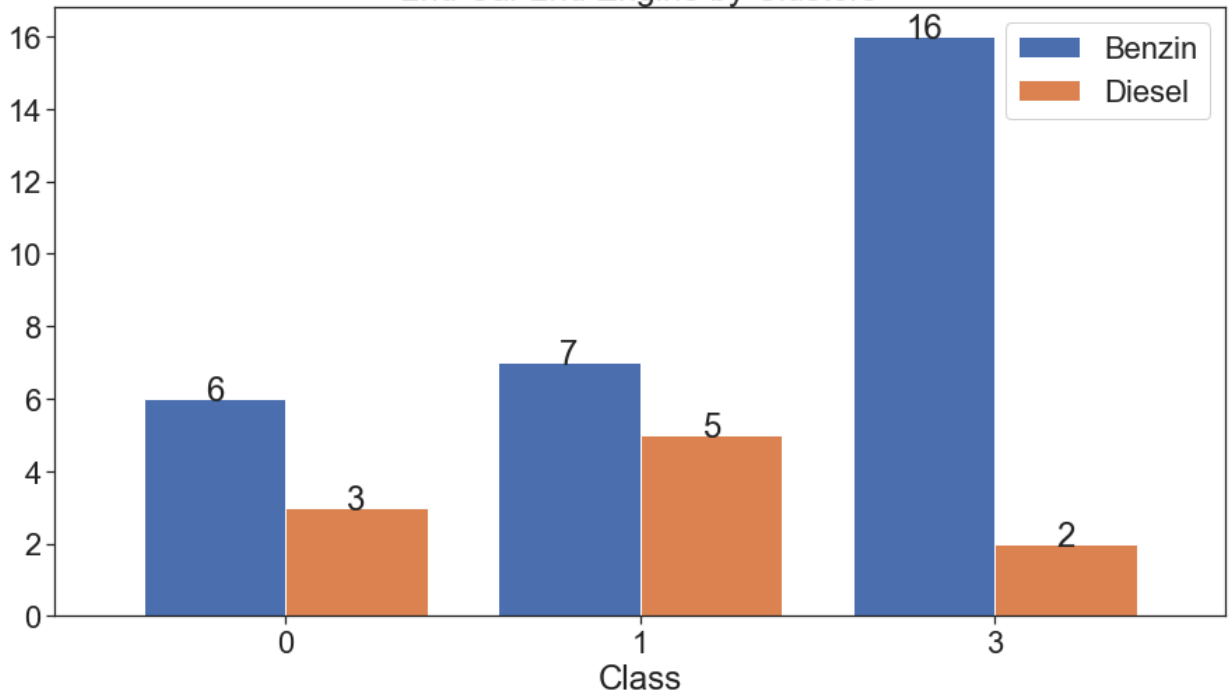
#df2_nonscale['engine_1'] = df2_nonscale['no_cars'].astype('int').astype('object')

ax2 = df2_nonscale.groupby(['cluster_id', 'engine_4']).size().unstack(level=1).plot(kind='bar')
ax2.legend(bbox_to_anchor=(1,1))
ax2.tick_params(axis='x', rotation=0)

for p in ax2.patches:
    ax2.annotate(round(p.get_height()),
                  xy=(p.get_x()+p.get_width()/2., p.get_height()+ 0.2),
                  ha='center',
                  va='center')

```

2nd Car 2nd Engine by Clusters



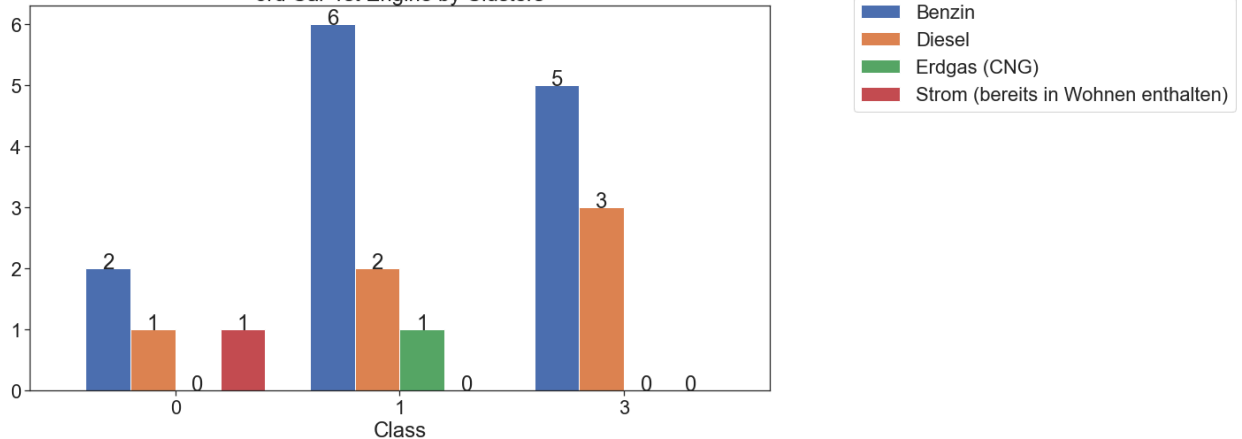
```
In [58]: sns.set_style("ticks")

#df2_nonscale['engine_1'] = df2_nonscale['no_cars'].astype('int').astype('object')

ax2 = df2_nonscale.groupby(['cluster_id', 'engine_5']).size().unstack(level=1).plot(kind='bar')
ax2.legend(bbox_to_anchor=(1.1, 1.05))
ax2.tick_params(axis='x', rotation=0)

for p in ax2.patches:
    ax2.annotate(round(p.get_height()),
                  xy=(p.get_x()+p.get_width()/2., p.get_height()+0.1),
                  ha='center',
                  va='center')
```

3rd Car 1st Engine by Clusters



```
In [78]: sns.set_style("ticks")

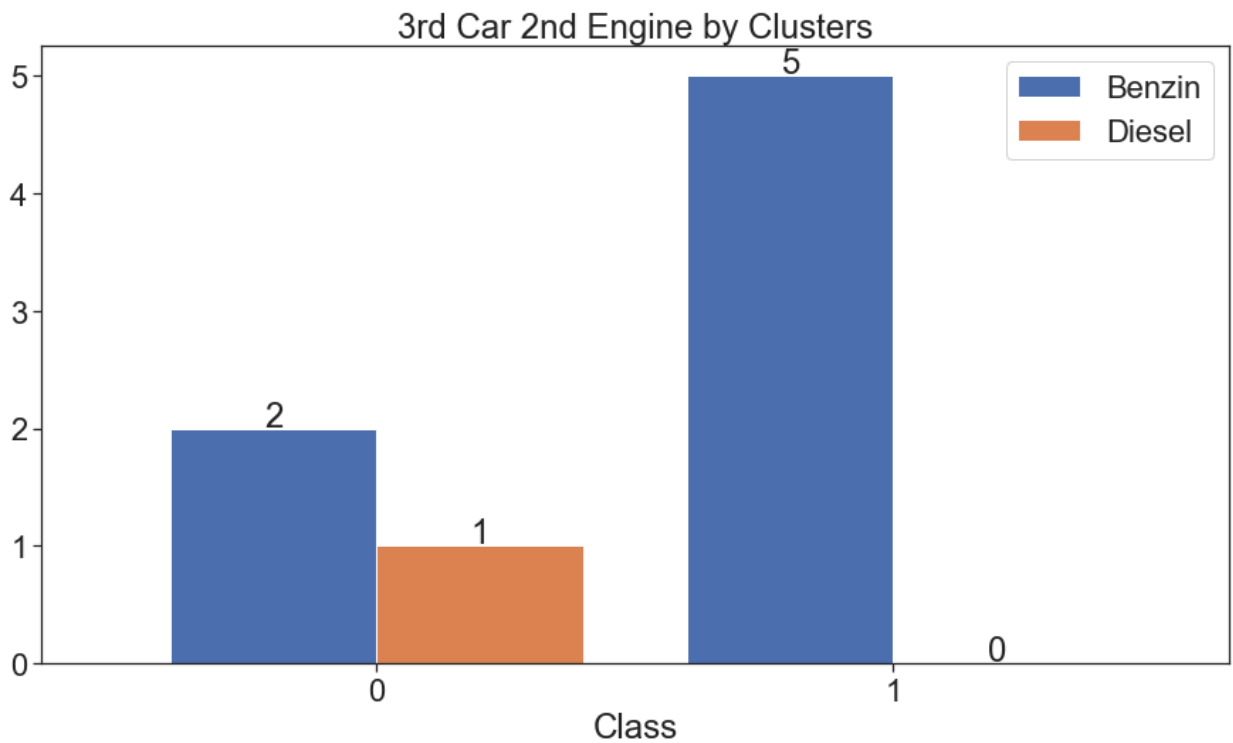
#df2_nonscale['engine_1'] = df2_nonscale['no_cars'].astype('int').astype('object')
```

```

ax2 = df2_nonscale.groupby(['cluster_id', 'engine_6']).size().unstack(level=1).plot(kind='bar')
ax2.legend(bbox_to_anchor=(1,1))
ax2.tick_params(axis='x', rotation=0)

for p in ax2.patches:
    ax2.annotate(round(p.get_height()),
                 xy=(p.get_x()+p.get_width()/2., p.get_height()+0.1),
                 ha='center',
                 va='center')

```



```

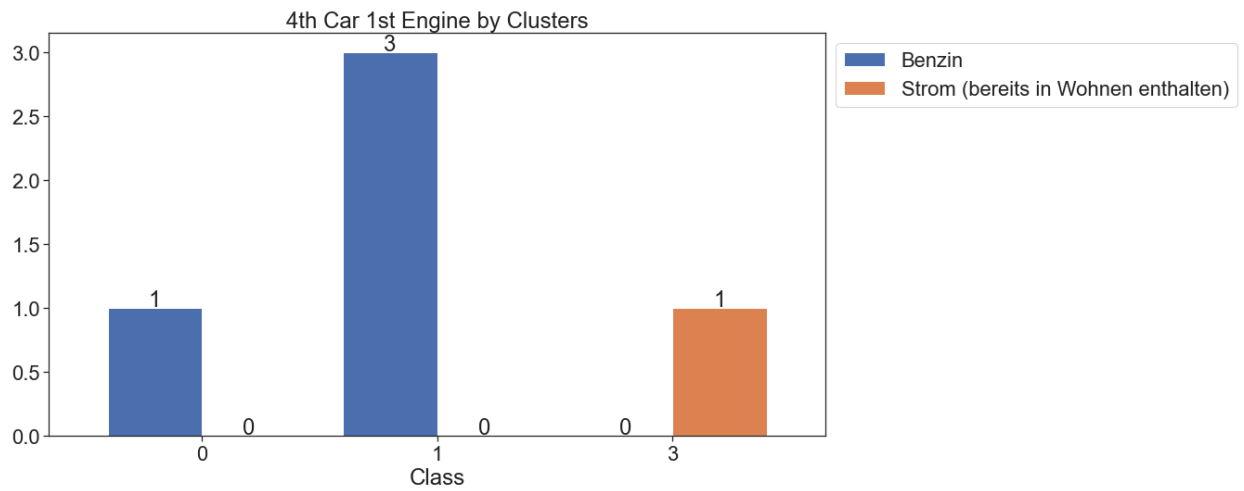
In [68]: sns.set_style("ticks")

#df2_nonscale['engine_1'] = df2_nonscale['no_cars'].astype('int').astype('object')

ax2 = df2_nonscale.groupby(['cluster_id', 'engine_7']).size().unstack(level=1).plot(kind='bar')
ax2.legend(bbox_to_anchor=(1, 1))
ax2.tick_params(axis='x', rotation=0)

for p in ax2.patches:
    ax2.annotate(round(p.get_height()),
                 xy=(p.get_x()+p.get_width()/2., p.get_height()+0.06),
                 ha='center',
                 va='center')

```

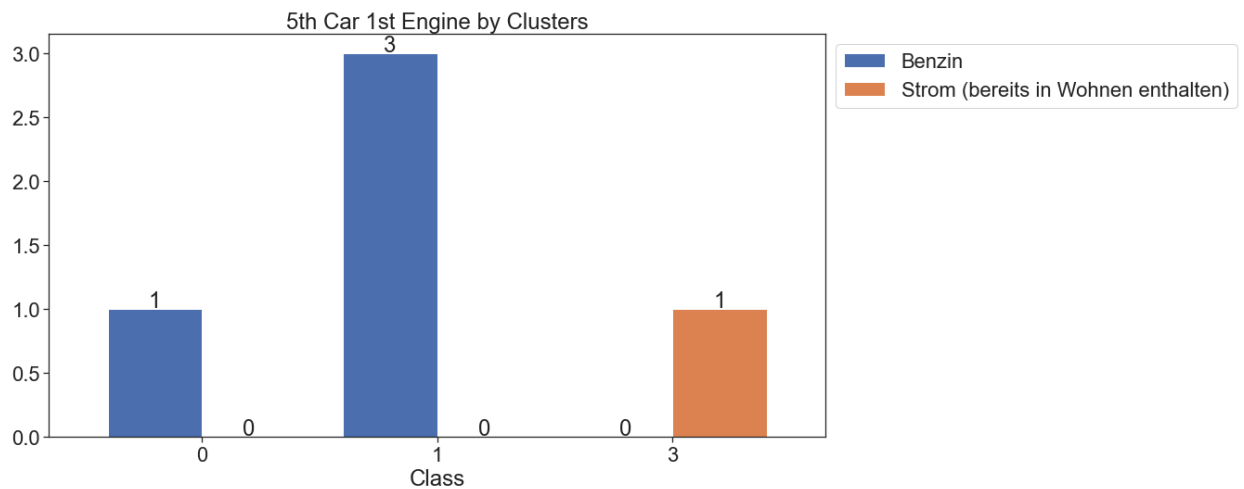


```
In [69]: sns.set_style("ticks")

#df2_nonscale['engine_1'] = df2_nonscale['no_cars'].astype('int').astype('object')

ax2 = df2_nonscale.groupby(['cluster_id', 'engine_7']).size().unstack(level=1).plot(kind='bar')
ax2.legend(bbox_to_anchor=(1, 1))
ax2.tick_params(axis='x', rotation=0)

for p in ax2.patches:
    ax2.annotate(round(p.get_height()),
                  xy=(p.get_x()+p.get_width()/2., p.get_height()+0.06),
                  ha='center',
                  va='center')
```



```
In [187... ## expected results for Class 0
cluster0 = df2_nonscale[df2_nonscale['cluster_id'] == 0]
cluster0.describe()
```

Out[187]:

	Unnamed: 0	age	income	CO2_cruise	CO2_flight	CO2_public_transport	CO2_car
count	64.000000	64.000000	64.000000	64.000000	64.000000	64.000000	64.000000
mean	239.718750	33.625000	3493.750000	9705.187500	5511.716875	84.218750	5392.000000
std	163.329686	13.448904	1864.528963	22273.238668	11962.816461	44.916667	14564.000000
min	1.000000	19.000000	400.000000	271.000000	0.000000	0.000000	0.000000
25%	109.750000	24.750000	2000.000000	1084.000000	798.000000	107.800000	1430.000000
50%	194.000000	31.000000	3100.000000	1897.000000	2644.040000	107.800000	2639.000000
75%	325.750000	38.000000	4500.000000	4268.250000	5725.550000	107.800000	4230.000000
max	584.000000	100.000000	8000.000000	98915.000000	91565.800000	107.800000	89545.000000

In [188... *## total emission from the car*

```
df2_nonscale['CO2_car_total'].sum()
```

Out[188]: 1623947.3301610001

In [189... `cluster0['CO2_car_total'].sum()`

Out[189]: 345088.018101

In [190... *## When Class 0 emission from car lowers to the level of Class 3*

```
round(100*(345088.018101 - (4319.52*64)) / 1623947.3301610001, 2)
```

Out[190]: 4.23

In [191... *## When Class 0 emission from car lowers to the level of Class 3*

```
round(100*(345088.018101 - (3501.75*64)) / 1623947.3301610001, 2)
```

Out[191]: 7.45

In [192... *## total emission from flights*

```
df2_nonscale['CO2_flight'].sum()
```

Out[192]: 1402588.28

In [193... `cluster0['CO2_flight'].sum()`

Out[193]: 352749.88

In [194... *## When Class 0 emission from flights lowers to the level of Class 1*

```
round(100*(352749.88 - (2965.06*64)) / 1402588.28, 2)
```

Out[194]: 11.62

```
In [195... ## expected results for Class 1

cluster1 = df2_nonscale[df2_nonscale['cluster_id'] == 1]
cluster1.describe()
```

Out[195]:

	Unnamed: 0	age	income	CO2_cruise	CO2_flight	CO2_public_transport	CO2_car_
count	176.000000	176.000000	176.000000	176.0	176.000000	1.760000e+02	176.00
mean	301.522727	33.096591	3820.977273	0.0	2965.058409	1.078000e+02	4319.52
std	168.228381	13.564946	1870.580906	0.0	9700.528625	3.562850e-13	8611.87
min	5.000000	18.000000	0.000000	0.0	0.000000	1.078000e+02	0.00
25%	158.750000	22.750000	2500.000000	0.0	0.000000	1.078000e+02	1074.54
50%	292.000000	28.500000	4000.000000	0.0	798.000000	1.078000e+02	2149.09
75%	436.000000	40.000000	5000.000000	0.0	2349.500000	1.078000e+02	3612.26
max	587.000000	74.000000	9000.000000	0.0	96159.000000	1.078000e+02	77784.30

◀

```
In [196... cluster1['CO2_car_total'].sum()
```

Out[196]: 760235.5327440001

```
In [197... ## When Class 1 emission from car lowers to the level of Class 3

round(100*(760235.5327440001 - (3501.75*176)) / 1623947.3301610001, 2)
```

Out[197]: 8.86