```python
import pandas as pd
import numpy as np
from sklearn.preprocessing import StandardScaler
from sklearn.cluster import KMeans
from sklearn.decomposition import PCA
import matplotlib.pyplot as plt
import seaborn as sns

np.random.seed(42)
data = pd.DataFrame({
    'Recency': np.random.randint(1, 100, 200),
    'Frequency': np.random.randint(1, 20, 200),
    'Monetary': np.random.uniform(10, 1000, 200),
    'Category_Preference': np.random.randint(1, 6, 200),  # 5
categories
    'Average_Session_Time': np.random.uniform(1, 60, 200)
})

data.fillna(data.mean(numeric_only=True),inplace=True)
print(data)
```

```
     Recency  Frequency    Monetary  Category_Preference
Average_Session_Time
0         52          5  447.928707                    1
1.312700
1         93          1  247.389486                    3
58.528963
2         15         19  102.934557                    5
29.954178
3         72         10  191.037337                    2
43.650870
4         61         12  935.267857                    1
49.430827
..       ...        ...         ...                  ...
...
195       70          5  556.071994                    2
58.756955
196       72          9  173.185919                    4
50.547543
197       27         12  417.142565                    4
52.152632
198        9          1  779.826261                    3
25.071085
199       62          1  485.566381                    4
33.551633

[200 rows x 5 columns]
```

```python
data.head()
```

```
   Recency  Frequency    Monetary  Category_Preference
Average_Session_Time
0       52          5  447.928707                    1
1.312700
1       93          1  247.389486                    3
58.528963
2       15         19  102.934557                    5
29.954178
3       72         10  191.037337                    2
43.650870
4       61         12  935.267857                    1
49.430827
```

```
data.describe()
```

```
          Recency   Frequency    Monetary  Category_Preference  \
count  200.000000  200.000000  200.000000           200.000000
mean    49.365000    9.450000  508.962607             2.920000
std     29.390488    6.024031  282.829078             1.433133
min      1.000000    1.000000   25.151495             1.000000
25%     24.000000    4.000000  265.799111             2.000000
50%     51.000000    9.000000  501.336329             3.000000
75%     75.000000   16.000000  739.681326             4.000000
max     99.000000   19.000000  995.971930             5.000000
```

```
       Average_Session_Time
count            200.000000
mean              31.407640
std               16.041248
min                1.159943
25%               18.594278
50%               32.456244
75%               45.079276
max               59.863864
```

```
Q1 = data.quantile(0.25)
Q3 = data.quantile(0.75)
IQR = Q3 - Q1
data_clean = data[~((data < (Q1 - 1.5 * IQR)) | (data > (Q3 + 1.5 *
IQR))).any(axis=1)]
data_clean
```

```
     Recency  Frequency    Monetary  Category_Preference
Average_Session_Time
0         52          5  447.928707                    1
1.312700
1         93          1  247.389486                    3
58.528963
2         15         19  102.934557                    5
29.954178
```

```
3         72         10  191.037337                    2
43.650870
4         61         12  935.267857                    1
49.430827
..       ...        ...         ...                  ...
...
195       70          5  556.071994                    2
58.756955
196       72          9  173.185919                    4
50.547543
197       27         12  417.142565                    4
52.152632
198        9          1  779.826261                    3
25.071085
199       62          1  485.566381                    4
33.551633

[200 rows x 5 columns]
```

```
scaler = StandardScaler()
data_scaled = scaler.fit_transform(data_clean)

data_scaled
```

```
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```

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       [-4.89990087e-01,  1.58929553e+00, -3.76708847e-01,
        -6.43561241e-01,  1.48731336e+00],
       [-5.58210079e-01, -9.06980171e-01,  1.36117187e+00,
         1.45500802e+00,  1.01289035e+00],
       [-1.51328996e+00, -1.07339855e+00, -1.25415579e+00,
         5.59618470e-02, -1.81545747e+00],
       [-2.85330114e-01,  1.25645877e+00,  3.27175066e-02,
        -1.34308433e+00,  5.01404825e-01],
       [-7.28760057e-01,  1.25645877e+00, -9.50183442e-01,
        -6.43561241e-01,  9.43430095e-01],
       [-1.44506997e+00,  4.24366869e-01,  2.71265604e-01,
        -1.34308433e+00, -5.19711508e-01],
       [ 8.06189747e-01,  7.57203629e-01,  1.26025492e+00,
        -1.34308433e+00, -1.64621672e+00],
       [ 7.72079751e-01, -5.74143411e-01,  1.32068724e+00,
         5.59618470e-02, -1.61524558e+00],
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         1.45500802e+00, -1.51596312e+00],
       [-5.24100083e-01, -7.48882710e-02,  1.41660491e+00,
        -1.34308433e+00,  1.19856170e+00],
       [-5.58210079e-01, -7.40561791e-01,  3.08403867e-01,
        -6.43561241e-01,  1.45757820e+00],
       [-4.65601441e-02,  1.25645877e+00, -5.39649579e-01,
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        -1.34308433e+00, -1.03050350e+00],
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         5.59618470e-02, -1.21333626e+00],
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         1.45500802e+00,  1.18768859e+00],
       [ 1.69304963e+00, -1.07339855e+00, -8.95805658e-01,
         7.55484935e-01, -6.75641374e-01],
       [-1.83000127e-01,  1.42287715e+00, -6.09711901e-01,
```

```
        -6.43561241e-01, -7.51975326e-01],
       [ 1.24961969e+00,  9.15301090e-02, -2.44062840e-01,
         7.55484935e-01, -1.06188350e+00],
       [ 1.42016967e+00, -1.07339855e+00, -8.78407317e-01,
        -6.43561241e-01,  3.41109773e-01],
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        -6.43561241e-01,  8.43885404e-01],
       [ 1.69304963e+00,  1.42287715e+00,  8.31563109e-01,
         5.59618470e-02, -1.14232381e+00],
       [-8.06701397e-02,  9.23622009e-01,  9.23576009e-01,
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         5.59618470e-02,  3.25723397e-01],
       [-1.58150995e+00,  9.15301090e-02,  8.42924960e-01,
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         7.55484935e-01, -3.71966384e-01],
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         1.45500802e+00,  1.28365788e+00],
       [ 1.38605967e+00, -2.41306651e-01, -3.64176719e-01,
        -6.43561241e-01,  1.50283560e+00],
       [-1.20630000e+00, -1.40623531e+00, -9.22471368e-02,
        -6.43561241e-01, -1.83195747e-01],
       [-7.62870053e-01, -7.48882710e-02, -1.47773481e+00,
         5.59618470e-02, -1.27382408e-01],
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        -1.34308433e+00,  2.64318524e-01],
       [-1.17219000e+00, -4.07725031e-01,  1.04609520e+00,
         1.45500802e+00, -1.77923370e+00],
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       [-2.51220118e-01, -1.07339855e+00,  1.82483258e-01,
        -6.43561241e-01, -9.85075101e-01],
       [ 9.42629730e-01,  1.42287715e+00, -6.36262481e-01,
        -1.34308433e+00,  2.29524658e-01],
       [ 5.57698429e-02,  5.90785249e-01, -1.61631229e+00,
        -1.34308433e+00, -1.29005889e+00],
       [ 4.65089791e-01, -4.07725031e-01,  1.47608336e+00,
        -6.43561241e-01, -1.77542666e+00],
       [ 1.59071965e+00, -9.06980171e-01,  1.45668624e+00,
         7.55484935e-01, -7.51868739e-01],
       [ 8.98798385e-02,  5.90785249e-01, -8.80835657e-01,
        -1.34308433e+00,  9.77533594e-01],
       [ 1.59071965e+00, -1.40623531e+00,  6.71677488e-01,
        -1.34308433e+00, -8.76814814e-01],
```

```
       [-1.54739995e+00, -2.41306651e-01, -1.50390161e+00,
         1.45500802e+00, -1.08879454e+00],
       [ 1.52249966e+00,  7.57203629e-01, -1.18533958e+00,
         7.55484935e-01, -1.11614075e+00],
       [-8.99310035e-01,  1.09004039e+00, -1.00779975e+00,
        -1.34308433e+00, -7.74469121e-04],
       [-1.17219000e+00,  7.57203629e-01, -7.35193455e-01,
         7.55484935e-01,  1.69671509e+00],
       [-2.17110122e-01,  4.24366869e-01,  1.72589154e+00,
        -6.43561241e-01, -2.07941362e-01],
       [-6.94650061e-01,  1.58929553e+00,  6.76990076e-01,
         5.59618470e-02,  1.54575501e-01],
       [-4.55880092e-01,  9.23622009e-01, -4.20396725e-01,
        -1.34308433e+00,  1.27301603e+00],
       [-1.24040999e+00, -1.23981693e+00,  8.17971700e-01,
         1.45500802e+00,  7.25871485e-02],
       [-5.92320074e-01, -1.23981693e+00,  1.44313617e+00,
        -6.43561241e-01, -1.22018719e+00],
       [ 7.37969756e-01,  1.58929553e+00,  1.59560113e+00,
         7.55484935e-01, -7.95663138e-01],
       [ 3.28649808e-01,  1.25645877e+00, -1.56555933e+00,
        -6.43561241e-01, -7.57533254e-01],
       [ 1.24961969e+00,  9.15301090e-02, -3.84182606e-01,
        -1.34308433e+00, -4.35337154e-01],
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       [ 5.67419778e-01,  9.23622009e-01, -5.90736149e-01,
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       [-2.51220118e-01,  2.57948489e-01, -1.17318230e+00,
        -6.43561241e-01, -6.12071059e-01],
       [-1.48890131e-01, -7.40561791e-01,  5.01264390e-01,
        -1.34308433e+00, -1.73860719e-01],
       [ 4.30979795e-01, -1.40623531e+00, -4.06126658e-01,
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         7.55484935e-01, -5.07578333e-01],
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        -6.43561241e-01,  1.18427428e+00],
       [-7.28760057e-01,  4.24366869e-01, -5.04113140e-01,
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```

```
        -1.34308433e+00, -1.26457018e-01],
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         1.45500802e+00, -1.52062928e+00],
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       [ 1.62482964e+00,  5.90785249e-01,  1.53183818e+00,
         5.59618470e-02, -1.62194790e+00],
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       [ 4.30979795e-01,  1.58929553e+00,  1.45689972e+00,
         5.59618470e-02,  1.40870082e+00],
       [ 9.42629730e-01,  1.25645877e+00, -1.47823627e+00,
         1.45500802e+00,  4.12777970e-02],
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       [ 7.72079751e-01, -7.48882710e-02, -1.19018629e+00,
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       [-7.62870053e-01,  4.24366869e-01, -3.25463199e-01,
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       [-1.37684997e+00, -1.40623531e+00,  9.60097048e-01,
         5.59618470e-02, -3.96007567e-01],
       [ 4.30979795e-01, -1.40623531e+00, -8.29297235e-02,
         7.55484935e-01,  1.33990431e-01]])
```

```
inertia = []
K = range(1, 10)
for k in K:
    kmeans = KMeans(n_clusters=k, random_state=42)
    kmeans.fit(data_scaled)
    inertia.append(kmeans.inertia_)
plt.figure(figsize=(8,4))
plt.plot(K, inertia, 'bx-')
plt.xlabel('Number of clusters')
plt.ylabel('Inertia')
plt.title('Elbow Method For Optimal k')
plt.show()
```

```
E:\Python\Lib\site-packages\sklearn\cluster\_kmeans.py:1419:
UserWarning: KMeans is known to have a memory leak on Windows with
MKL, when there are less chunks than available threads. You can avoid
it by setting the environment variable OMP_NUM_THREADS=1.
  warnings.warn(
```

```
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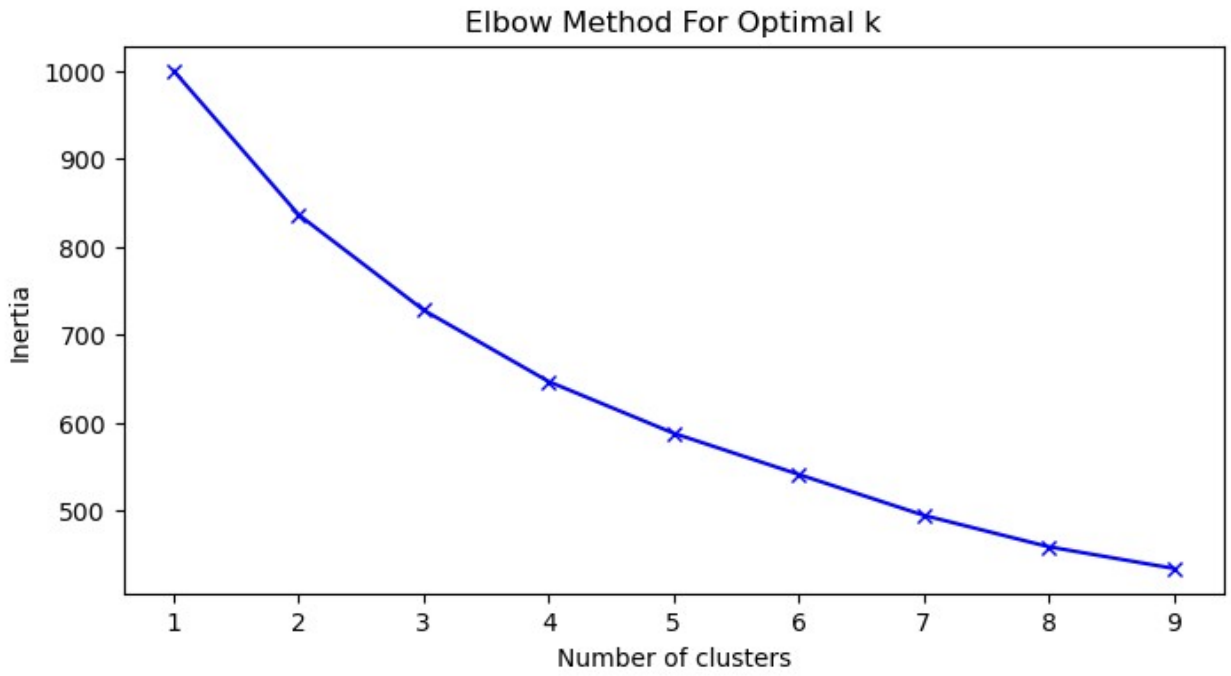
MKL, when there are less chunks than available threads. You can avoid
it by setting the environment variable OMP_NUM_THREADS=1.
  warnings.warn(
```




```
k_optimal = 4
kmeans = KMeans(n_clusters=k_optimal, random_state=42)
clusters = kmeans.fit_predict(data_scaled)
data_clean['Cluster'] = clusters
```

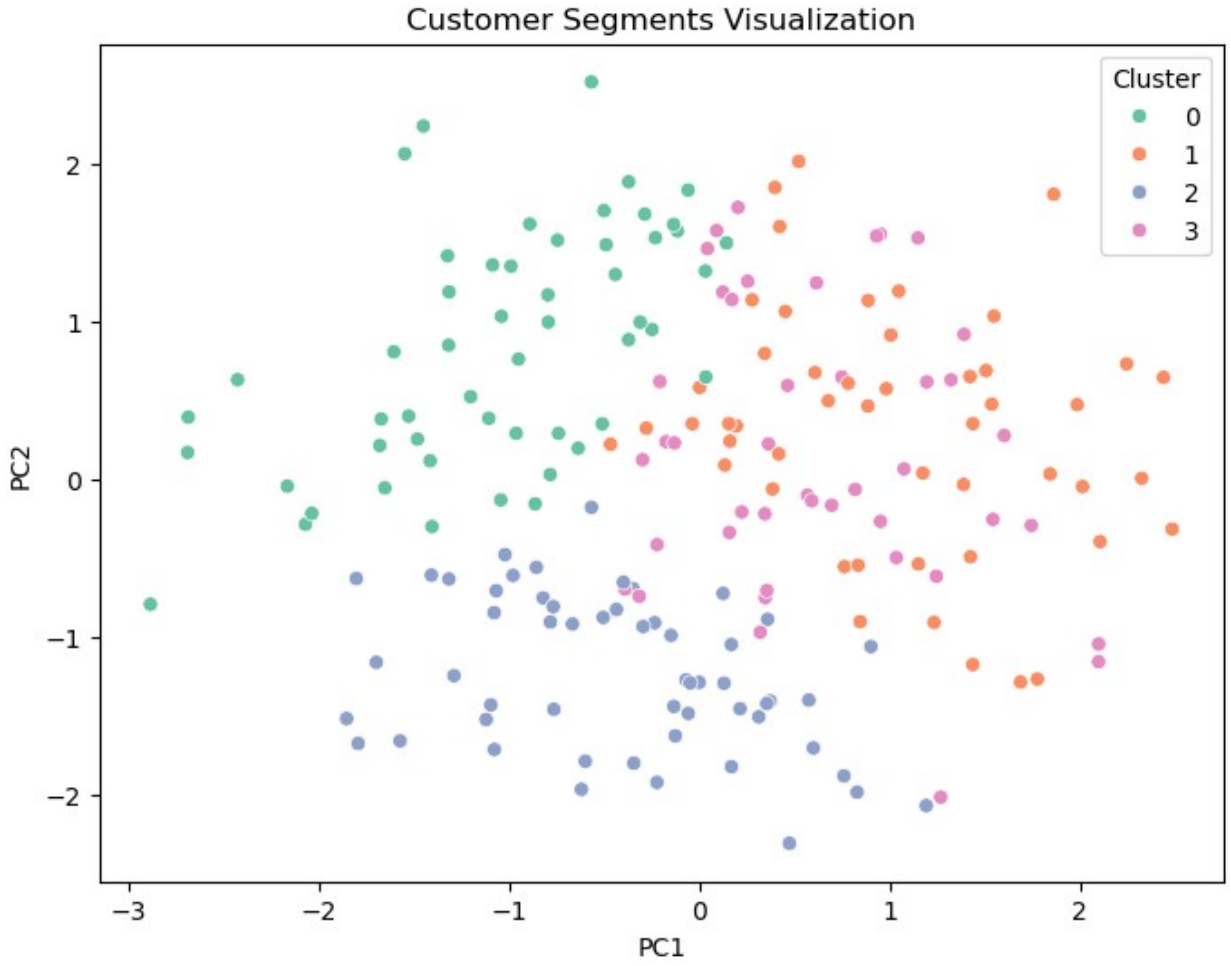
```
E:\Python\Lib\site-packages\sklearn\cluster\_kmeans.py:1419:
UserWarning: KMeans is known to have a memory leak on Windows with
MKL, when there are less chunks than available threads. You can avoid
it by setting the environment variable OMP_NUM_THREADS=1.
  warnings.warn(
```

```
clusters
```

```
array([1, 3, 0, 2, 2, 2, 3, 2, 0, 1, 3, 3, 0, 2, 0, 0, 2, 0, 3, 0, 0,
3,
       1, 0, 3, 2, 0, 3, 1, 2, 1, 1, 3, 3, 3, 2, 2, 3, 1, 3, 2, 1, 1,
0,
       3, 1, 2, 3, 3, 0, 2, 2, 0, 0, 2, 2, 3, 0, 1, 2, 2, 2, 3, 0, 2,
0,
       1, 3, 1, 1, 0, 2, 0, 0, 0, 1, 3, 2, 2, 3, 3, 0, 3, 0, 1, 1, 2,
0,
       3, 1, 2, 1, 1, 3, 3, 3, 0, 0, 0, 1, 0, 2, 3, 0, 3, 3, 1, 0, 1,
1,
       0, 2, 1, 1, 1, 3, 0, 2, 2, 3, 0, 2, 2, 2, 1, 1, 0, 2, 3, 0, 2,
1,
       1, 3, 1, 2, 1, 3, 0, 2, 1, 2, 3, 1, 0, 0, 3, 0, 0, 0, 2, 1, 3,
1,
       2, 2, 1, 1, 2, 1, 0, 1, 2, 0, 1, 2, 2, 0, 1, 1, 2, 2, 0, 2, 2,
1,
```

```
       3, 0, 2, 2, 0, 3, 0, 0, 2, 2, 3, 1, 0, 1, 2, 1, 2, 0, 2, 3, 0,
0,
       1, 3], dtype=int32)
```

```
pca = PCA(n_components=2)
principal_components = pca.fit_transform(data_scaled)
data_clean['PC1'] = principal_components[:, 0]
data_clean['PC2'] = principal_components[:, 1]
plt.figure(figsize=(8,6))
sns.scatterplot(x='PC1', y='PC2', hue='Cluster', data=data_clean,
palette='Set2')
plt.title('Customer Segments Visualization')
plt.show()
```




```
segment_summary = data_clean.groupby('Cluster').mean()
print("Segment Profiles:\n", segment_summary)
```

```
Segment Profiles:
            Recency  Frequency    Monetary  Category_Preference  \
Cluster
```

```
0        28.849057   9.566038  276.791639             4.075472
1        59.183673   7.591837  668.039948             2.877551
2        46.800000  14.763636  493.004172             1.636364
3        66.744186   4.627907  634.264599             3.186047

         Average_Session_Time       PC1       PC2
Cluster
0                   31.825490 -1.045620  0.837497
1                   13.939471  1.030077  0.317946
2                   37.042635 -0.408095 -1.230807
3                   43.590650  0.636961  0.179714
```

```python
for cluster_id, row in segment_summary.iterrows():
    print(f"\nCluster {cluster_id} characteristics:")
    print(f"- Average Recency: {row['Recency']:.2f} days")
    print(f"- Average Frequency: {row['Frequency']:.2f} purchases")
    print(f"- Average Monetary: ${row['Monetary']:.2f}")
    print(f"- Preferred Category:
{int(round(row['Category_Preference']))}")
    print(f"- Average Session Time: {row['Average_Session_Time']:.2f}
minutes")

    if row['Frequency'] > 10 and row['Monetary'] > 500:
        print("Recommendation: Target with loyalty programs and
premium offers.")
    elif row['Recency'] > 50:
        print("Recommendation: Re-engagement campaigns with
discounts.")
    else:
        print("Recommendation: Personalized product recommendations
based on preferences.")
```

```
Cluster 0 characteristics:
- Average Recency: 28.85 days
- Average Frequency: 9.57 purchases
- Average Monetary: $276.79
- Preferred Category: 4
- Average Session Time: 31.83 minutes
Recommendation: Personalized product recommendations based on
preferences.

Cluster 1 characteristics:
- Average Recency: 59.18 days
- Average Frequency: 7.59 purchases
- Average Monetary: $668.04
- Preferred Category: 3
- Average Session Time: 13.94 minutes
Recommendation: Re-engagement campaigns with discounts.
```

```
Cluster 2 characteristics:
- Average Recency: 46.80 days
- Average Frequency: 14.76 purchases
- Average Monetary: $493.00
- Preferred Category: 2
- Average Session Time: 37.04 minutes
Recommendation: Personalized product recommendations based on
preferences.

Cluster 3 characteristics:
- Average Recency: 66.74 days
- Average Frequency: 4.63 purchases
- Average Monetary: $634.26
- Preferred Category: 3
- Average Session Time: 43.59 minutes
Recommendation: Re-engagement campaigns with discounts.
```