In [1]:
```
import numpy as np
import pandas as pd

import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline

import math
import datetime
import scipy
import scipy.stats as stats

from sklearn.preprocessing import StandardScaler
from sklearn.cluster import KMeans
from sklearn.metrics import silhouette_score
from scipy.cluster.hierarchy import linkage
from scipy.cluster.hierarchy import dendrogram
from scipy.cluster.hierarchy import cut_tree

import warnings
warnings.filterwarnings("ignore")
```

In [2]:
```
df = pd.read_excel("Online Retail.xlsx")
```

In [3]:
```
df.head()
```

Out[3]:

	InvoiceNo	StockCode	Description	Quantity	InvoiceDate	UnitPrice	CustomerID	Country
0	536365	85123A	WHITE HANGING HEART T-LIGHT HOLDER	6	2010-12-01 08:26:00	2.55	17850.0	United Kingdom
1	536365	71053	WHITE METAL LANTERN	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom
2	536365	84406B	CREAM CUPID HEARTS COAT HANGER	8	2010-12-01 08:26:00	2.75	17850.0	United Kingdom
3	536365	84029G	KNITTED UNION FLAG HOT WATER BOTTLE	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom
4	536365	84029E	RED WOOLLY HOTTIE WHITE HEART.	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom

In [4]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 541909 entries, 0 to 541908
Data columns (total 8 columns):
 #   Column       Non-Null Count   Dtype         
---  ------       --------------   -----         
 0   InvoiceNo    541909 non-null  object        
 1   StockCode    541909 non-null  object        
 2   Description  540455 non-null  object        
 3   Quantity     541909 non-null  int64         
 4   InvoiceDate  541909 non-null  datetime64[ns]
 5   UnitPrice    541909 non-null  float64       
 6   CustomerID   406829 non-null  float64       
 7   Country      541909 non-null  object        
dtypes: datetime64[ns](1), float64(2), int64(1), object(4)
memory usage: 33.1+ MB
```

In [5]:
```
df.shape
```

Out[5]:
```
(541909, 8)
```

In [6]:
```
df.describe()
```

Out[6]:

	Quantity	UnitPrice	CustomerID
count	541909.000000	541909.000000	406829.000000
mean	9.552250	4.611114	15287.690570
std	218.081158	96.759853	1713.600303
min	-80995.000000	-11062.060000	12346.000000
25%	1.000000	1.250000	13953.000000
50%	3.000000	2.080000	15152.000000
75%	10.000000	4.130000	16791.000000
max	80995.000000	38970.000000	18287.000000

In [7]:
```
# Checking for NUlls

df.isnull().sum()
```

Out[7]:
```
InvoiceNo          0
StockCode          0
Description     1454
Quantity           0
InvoiceDate        0
UnitPrice          0
CustomerID     135080
Country            0
dtype: int64
```

In [8]:
```
# Customers cannot be segmented without the Customer IDs. dropping the records

df.dropna(inplace=True)
```

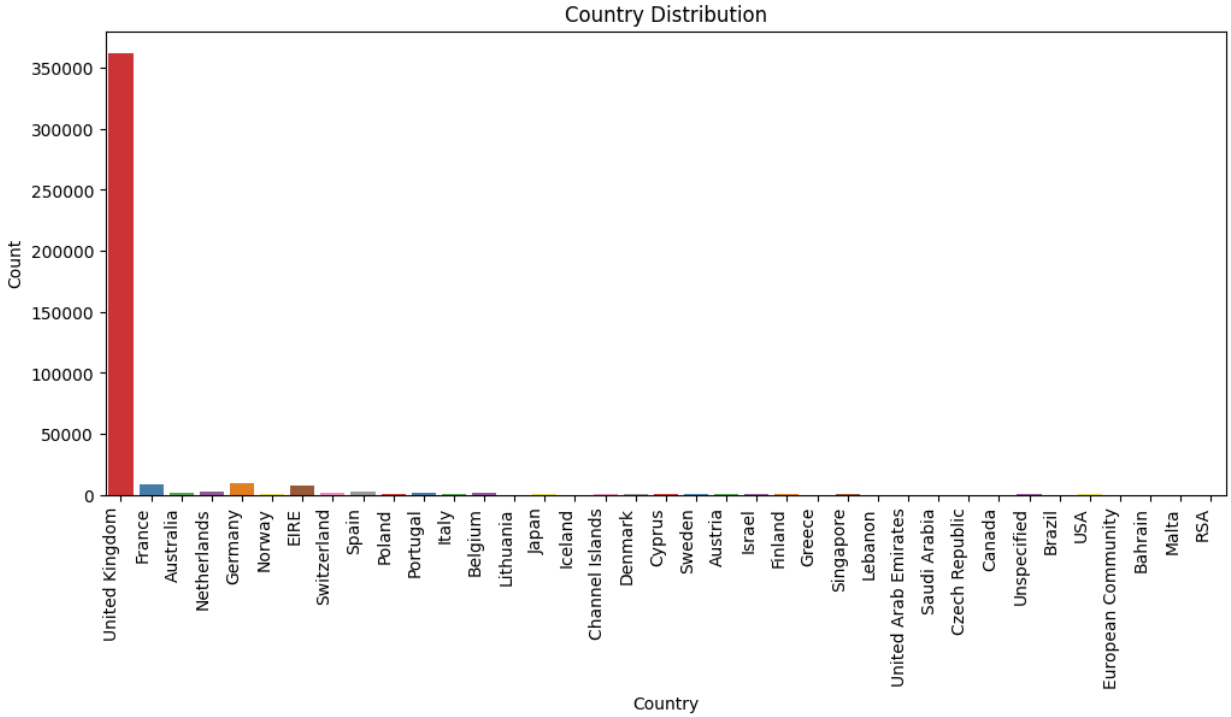
In [9]:
```
df.shape
```

Out[9]:
```
(406829, 8)
```

Fundamental Analysis

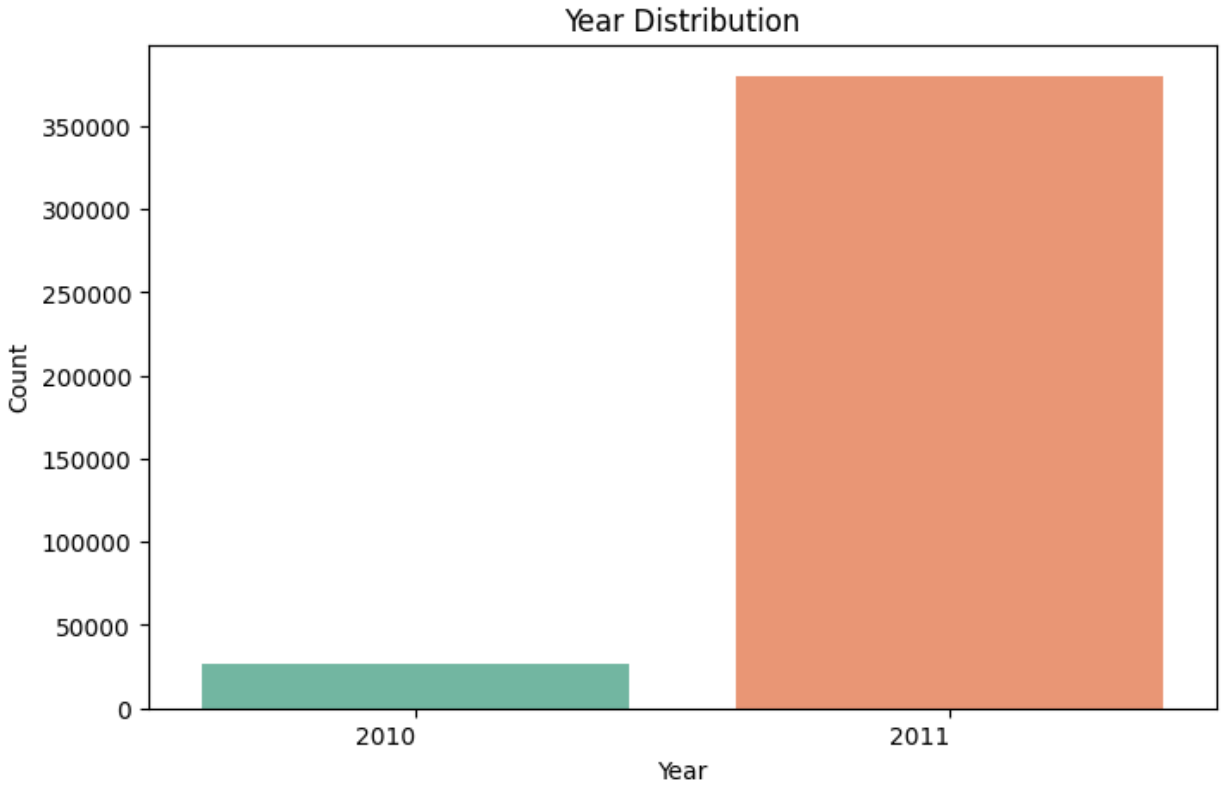
Country Distribution

In [10]:
```
plt.figure(figsize=(12,5))
sns.countplot(x=df['Country'], palette='Set1')
plt.xticks(rotation=90,ha='right')
plt.title("Country Distribution")
plt.xlabel('Country')
plt.ylabel('Count');
```



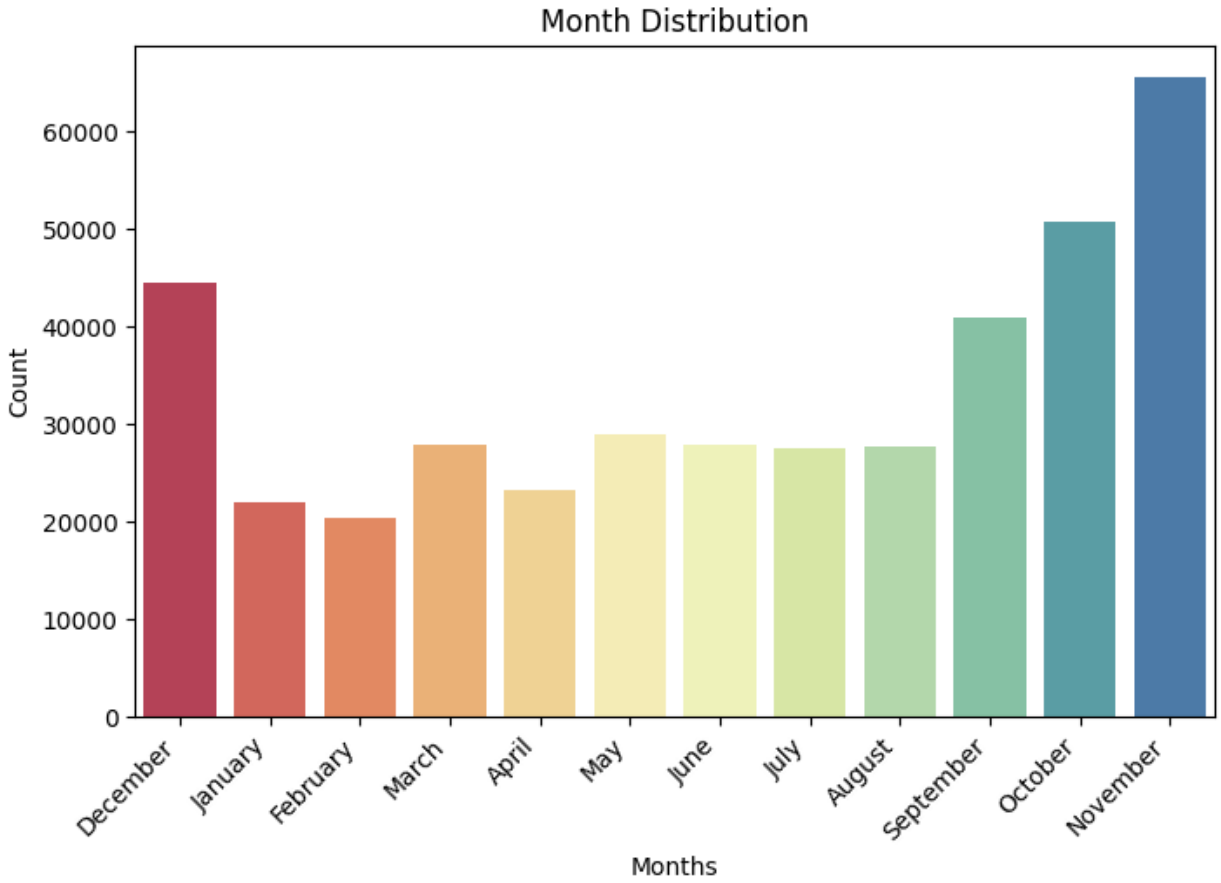
Year Distribution

In [11]:
```
plt.figure(figsize=(8,5))
df['InvoiceDate'] = pd.to_datetime(df['InvoiceDate'], errors='coerce')
sns.countplot(x=df['InvoiceDate'].dt.year,palette= 'Set2')
plt.xticks(rotation=0,ha='right')
plt.title("Year Distribution")
plt.xlabel('Year')
plt.ylabel('Count');
```



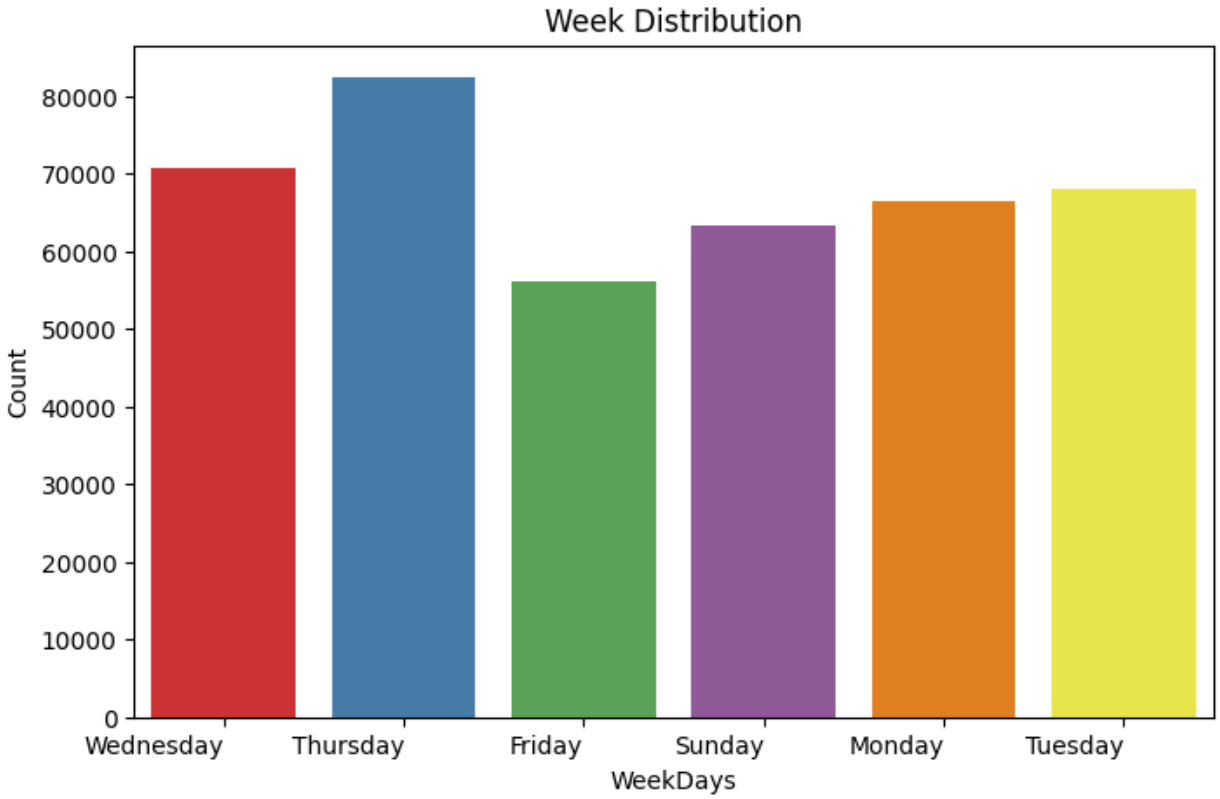
Month Distribution

In [12]:
```
plt.figure(figsize=(8,5))
df['InvoiceDate'] = pd.to_datetime(df['InvoiceDate'], errors='coerce')
sns.countplot(x=df['InvoiceDate'].dt.month_name(),palette= 'Spectral')
plt.xticks(rotation=45,ha='right')
plt.title("Month Distribution")
plt.xlabel('Months')
plt.ylabel('Count');
```



Week Distribution

In [13]:
```
plt.figure(figsize=(8,5))
df['InvoiceDate'] = pd.to_datetime(df['InvoiceDate'], errors='coerce')
sns.countplot(x=df['InvoiceDate'].dt.day_name(),palette= 'Set1')
plt.xticks(rotation=0,ha='right')
plt.title("Week Distribution")
plt.xlabel('WeekDays')
plt.ylabel('Count');
```



Recency, Frequency and Monetary Fields Calculation

In [14]:
```
df['Monetary'] = df['Quantity']*df['UnitPrice']
df_m = df.groupby('CustomerID')['Monetary'].sum()
df_m = df_m.reset_index()
df_m = df_m[~(df_m['Monetary']<=0)]
df_m.head()
```

Out[14]:

	CustomerID	Monetary
1	12347.0	4310.00
2	12348.0	1797.24
3	12349.0	1757.55
4	12350.0	334.40
5	12352.0	1545.41

In [15]:
```
df_f = df.groupby('CustomerID')['InvoiceNo'].count()
df_f = df_f.reset_index()
df_f.columns = ['CustomerID', 'Frequency']
df_f.head()
```

Out[15]:

	CustomerID	Frequency
0	12346.0	2
1	12347.0	182
2	12348.0	31
3	12349.0	73
4	12350.0	17

In [16]:
```
df['InvoiceDate'] = pd.to_datetime(df['InvoiceDate'], format='%d-%m-%Y %H:%M')
max_date = max(df['InvoiceDate'])
max_date
```

Out[16]:
```
Timestamp('2011-12-09 12:50:00')
```

In [17]:
```
df['diff_days'] = max_date+datetime.timedelta(days=1) - df['InvoiceDate']
df.head()
```

Out[17]:

	InvoiceNo	StockCode	Description	Quantity	InvoiceDate	UnitPrice	CustomerID	Country
0	536365	85123A	WHITE HANGING HEART T-LIGHT HOLDER	6	2010-12-01 08:26:00	2.55	17850.0	United Kingdom
1	536365	71053	WHITE METAL LANTERN	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom
2	536365	84406B	CREAM CUPID HEARTS COAT HANGER	8	2010-12-01 08:26:00	2.75	17850.0	United Kingdom
3	536365	84029G	KNITTED UNION FLAG HOT WATER BOTTLE	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom
4	536365	84029E	RED WOOLLY HOTTIE WHITE HEART.	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom

In [18]:
```
df_r = df.groupby('CustomerID')['diff_days'].min()
df_r = df_r.reset_index()
df_r.head()
```

Out[18]:

	CustomerID	diff_days
0	12346.0	326 days 02:33:00
1	12347.0	2 days 20:58:00
2	12348.0	75 days 23:37:00
3	12349.0	19 days 02:59:00
4	12350.0	310 days 20:49:00

In [19]:
```
df_r['Recency'] = df_r['diff_days'].dt.days
df_r.drop('diff_days', axis=1, inplace=True)
df_r.head()
```

Out[19]:

	CustomerID	Recency
0	12346.0	326
1	12347.0	2
2	12348.0	75
3	12349.0	19
4	12350.0	310

RFM Dataframe Creation

In [20]:
```
df_rfm = pd.merge(df_r, df_f, on="CustomerID", how='inner')
df_rfm = pd.merge(df_rfm, df_m, on="CustomerID", how="inner")

df_rfm.head()
```

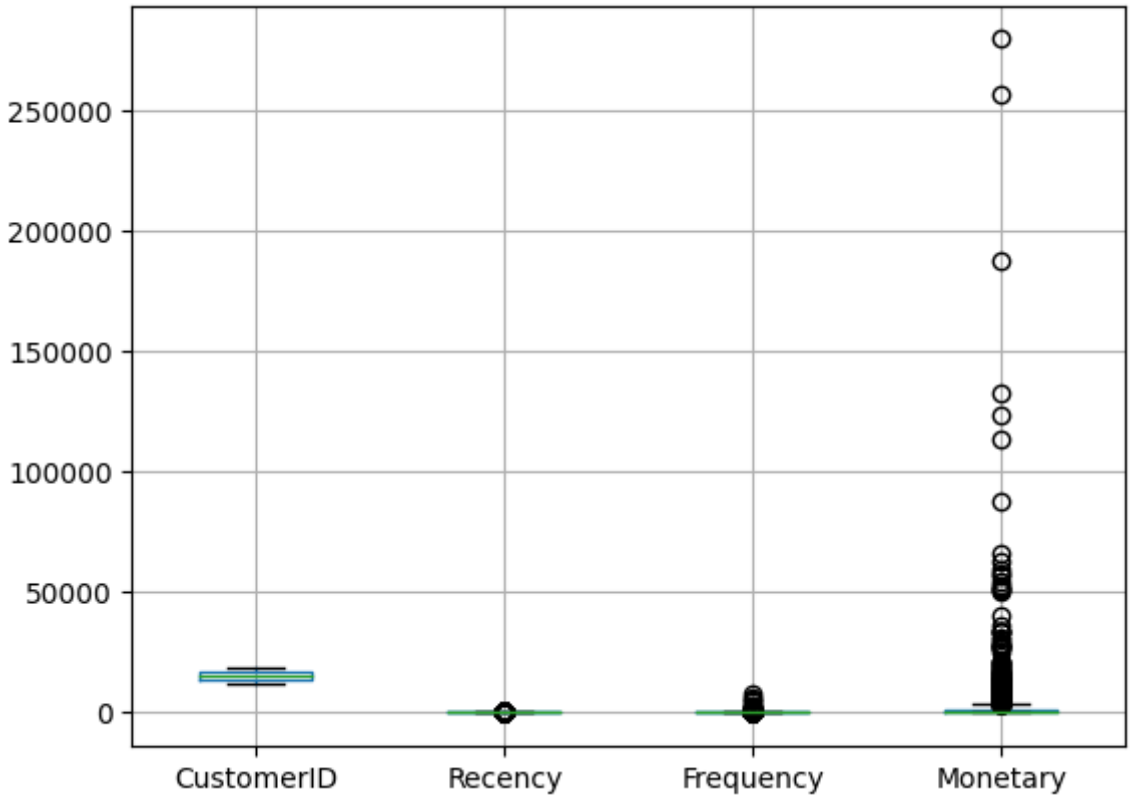
Out[20]:

	CustomerID	Recency	Frequency	Monetary
0	12347.0	2	182	4310.00
1	12348.0	75	31	1797.24
2	12349.0	19	73	1757.55
3	12350.0	310	17	334.40
4	12352.0	36	95	1545.41

Outliers Handling

In [21]:
```
df_rfm.boxplot()
```

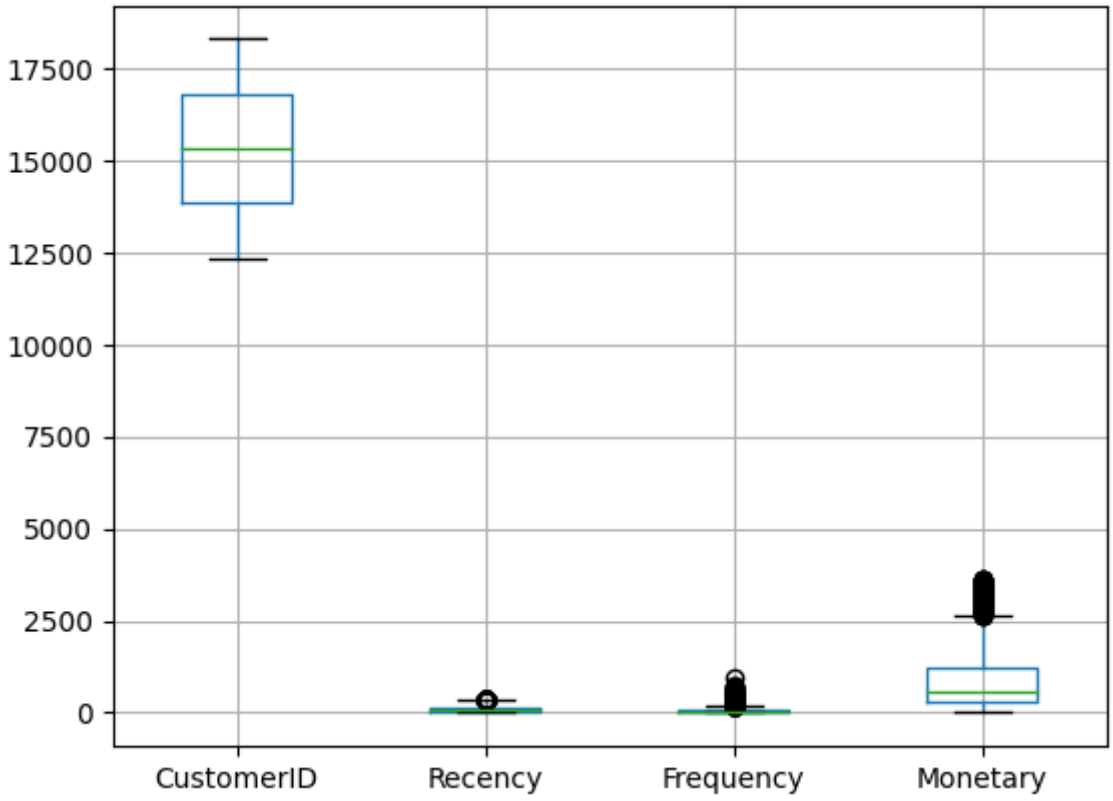
Out[21]:
```
<AxesSubplot: >
```



In [22]:
```
def outliers_removal(df, col):
    Q1 = df_rfm[col].quantile(0.25)
    Q3 = df_rfm[col].quantile(0.75)
    IQR = Q3 - Q1
    return df[(df[col] >= Q1 - 1.5*IQR) & (df[col] <= Q3 + 1.5*IQR)]
    return df
```

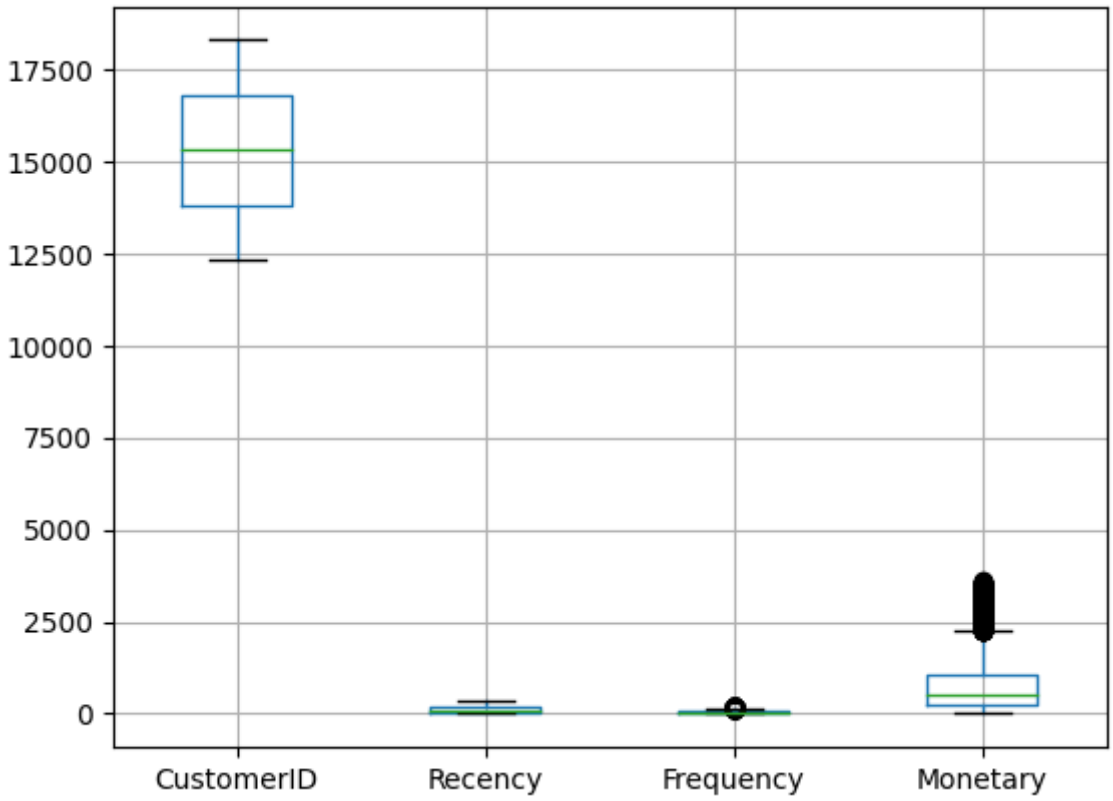
In [23]:
```
df_rfm = outliers_removal(df_rfm, 'Monetary')
df_rfm.boxplot()
```

Out[23]: <AxesSubplot: >



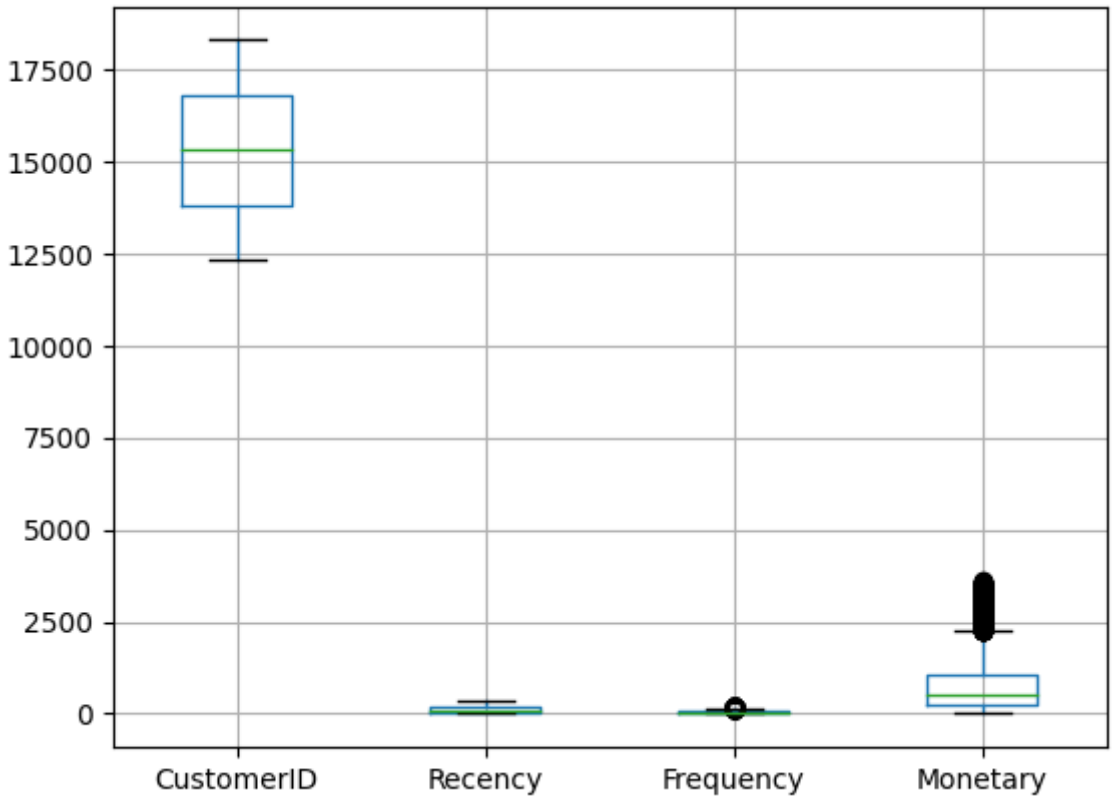
In [24]:
```
df_rfm = outliers_removal(df_rfm, 'Frequency')
df_rfm.boxplot()
```

Out[24]: <AxesSubplot: >



In [25]:
```
df_rfm = outliers_removal(df_rfm, 'Recency')
df_rfm.boxplot()
```

Out[25]: <AxesSubplot: >



Rescaling Different Attributes

In [26]:
```
df_rfm['Recency_log'] = df_rfm.Recency.apply(math.log)
df_rfm['Frequency_log'] = df_rfm.Frequency.apply(math.log)
df_rfm['Monetary_log'] = df_rfm.Monetary.apply(math.log)
df_rfm.head()
rfm_scaled = df_rfm[['Recency_log', 'Frequency_log', 'Monetary_log']]
rfm_scaled.columns = ['Recency', 'Frequency', 'Monetary']
rfm_scaled.head()
```

Out[26]:

	Recency	Frequency	Monetary
1	4.317488	3.433987	7.494007
2	2.944439	4.290459	7.471676
3	5.736572	2.833213	5.812338
4	3.583519	4.553877	7.343045
5	5.318120	1.386294	4.488636

k-Means with some of the arbitaries

In [27]:
```
km = KMeans(n_clusters=5, max_iter=50)
km.fit(rfm_scaled)
```

Out[27]:
```
KMeans
KMeans(max_iter=50, n_clusters=5)
```

In [28]:
```
km.labels_
```

Out[28]:
```
array([1, 3, 4, ..., 4, 0, 1], dtype=int32)
```

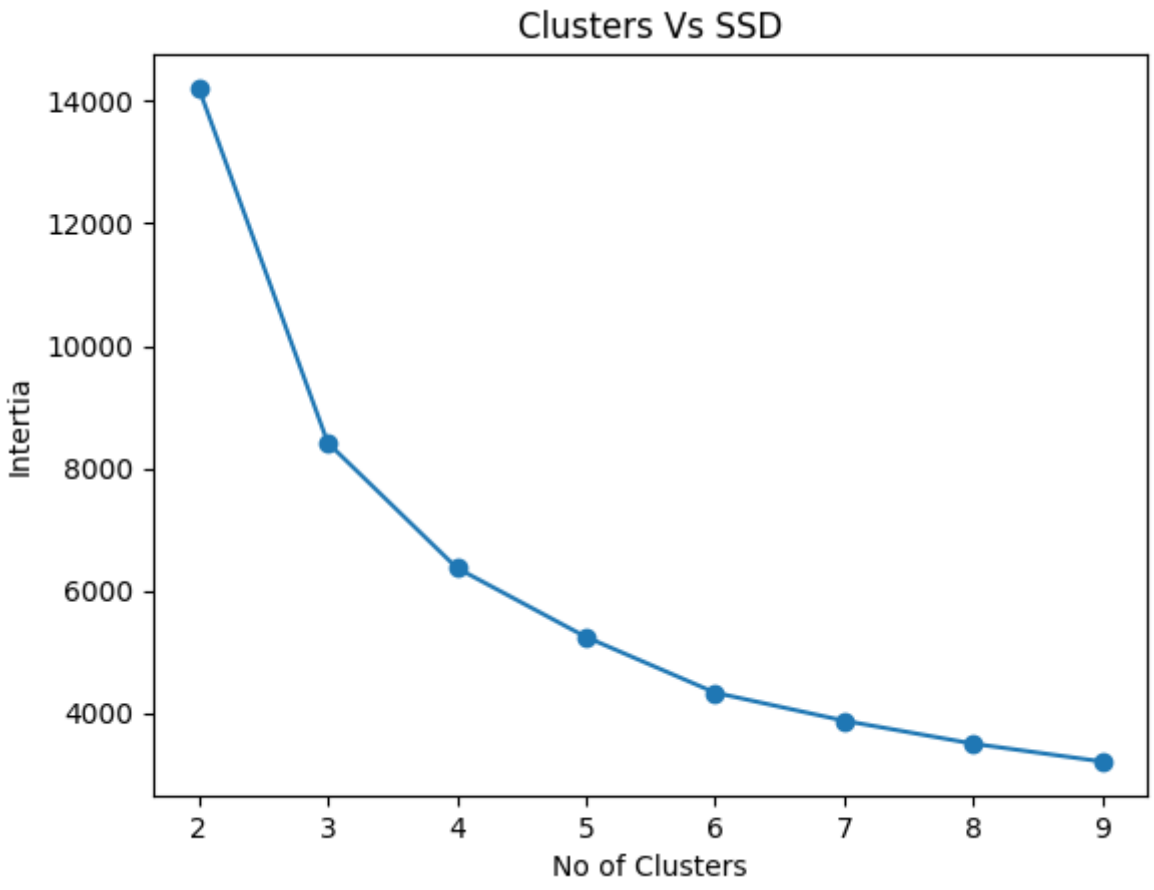
Elbow-curve Vs SSD

In [29]:
```
ssd = []
range_n_clusters = list(range(2,10))
for num_clusters in range_n_clusters:
    kmeans = KMeans(n_clusters=num_clusters, max_iter=50)
    kmeans.fit(rfm_scaled)

    ssd.append(kmeans.inertia_)


plt.plot(range_n_clusters,ssd, marker='o')
plt.title('Clusters Vs SSD')
plt.xlabel('No of Clusters')
plt.ylabel('Intertia')
```

Out[29]:
```
Text(0, 0.5, 'Intertia')
```



In [30]:
```
for n in range_n_clusters:
```

```
    km = KMeans(n_clusters=n, max_iter=50)
    km.fit(rfm_scaled)
    labels = km.labels_
    silhouette_avg = silhouette_score(rfm_scaled, labels)
    print(f"For n_clusters={n}, Silhouette Score is {silhouette_avg}")
```

```
For n_clusters=2, Silhouette Score is 0.36209603555796555
For n_clusters=3, Silhouette Score is 0.3676177055849174
For n_clusters=4, Silhouette Score is 0.3006161361531058
For n_clusters=5, Silhouette Score is 0.31026406500019454
For n_clusters=6, Silhouette Score is 0.30246299892071443
For n_clusters=7, Silhouette Score is 0.2754947018604492
For n_clusters=8, Silhouette Score is 0.27622811714725787
For n_clusters=9, Silhouette Score is 0.27997701088549426
```

In [31]:
```
import timeit
st = timeit.default_timer()

def km_fit(df):
    km = KMeans(n_clusters=2, max_iter=50)
    km.fit(df)
    return km

km_times = []
for i in range(100):
    st = timeit.default_timer()
    km = km_fit(rfm_scaled)
    km_times.append(timeit.default_timer() - st)


km = km_fit(rfm_scaled)
km_time = np.mean(km_times)

km_time
```

Out[31]:
```
0.09240218752049259
```

In [32]:
```
y = km.labels_
```

In [33]:
```
sum(y==0)
```

Out[33]:
```
1840
```

In [34]:
```
df_rfm['label'] = km.labels_
df_rfm.head()
```

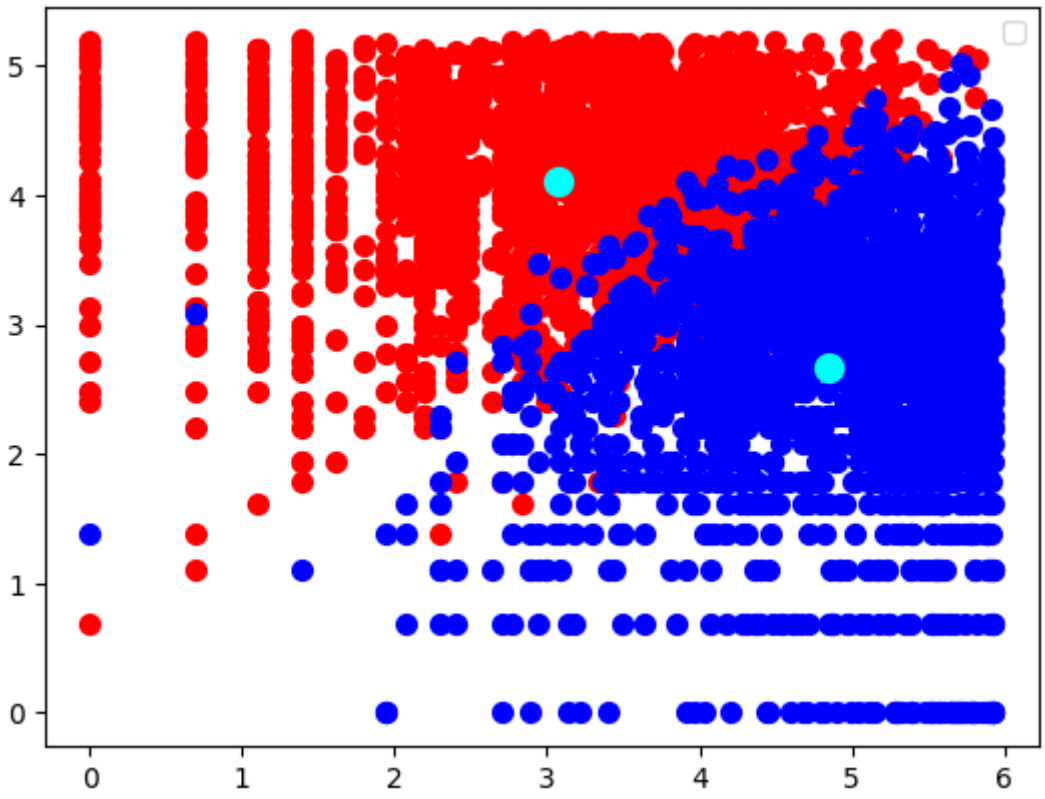
Out[34]:

	CustomerID	Recency	Frequency	Monetary	Recency_log	Frequency_log	Monetary_log	lal
1	12348.0	75	31	1797.24	4.317488	3.433987	7.494007	
2	12349.0	19	73	1757.55	2.944439	4.290459	7.471676	
3	12350.0	310	17	334.40	5.736572	2.833213	5.812338	
4	12352.0	36	95	1545.41	3.583519	4.553877	7.343045	
5	12353.0	204	4	89.00	5.318120	1.386294	4.488636	

In [35]:
```
X=rfm_scaled.values
plt.scatter(X[y==0, 0], X[y==0, 1], s=50, c='red')
plt.scatter(X[y==1, 0], X[y==1, 1], s=50, c='blue')
# plt.scatter(X[y==2, 0], X[y==2, 1], s=50, c='green')
plt.scatter(km.cluster_centers_[:,0], km.cluster_centers_[:,1], s=100, color='c
plt.legend()
```

```
No artists with labels found to put in legend.  Note that artists whose label
start with an underscore are ignored when legend() is called with no argument.
```

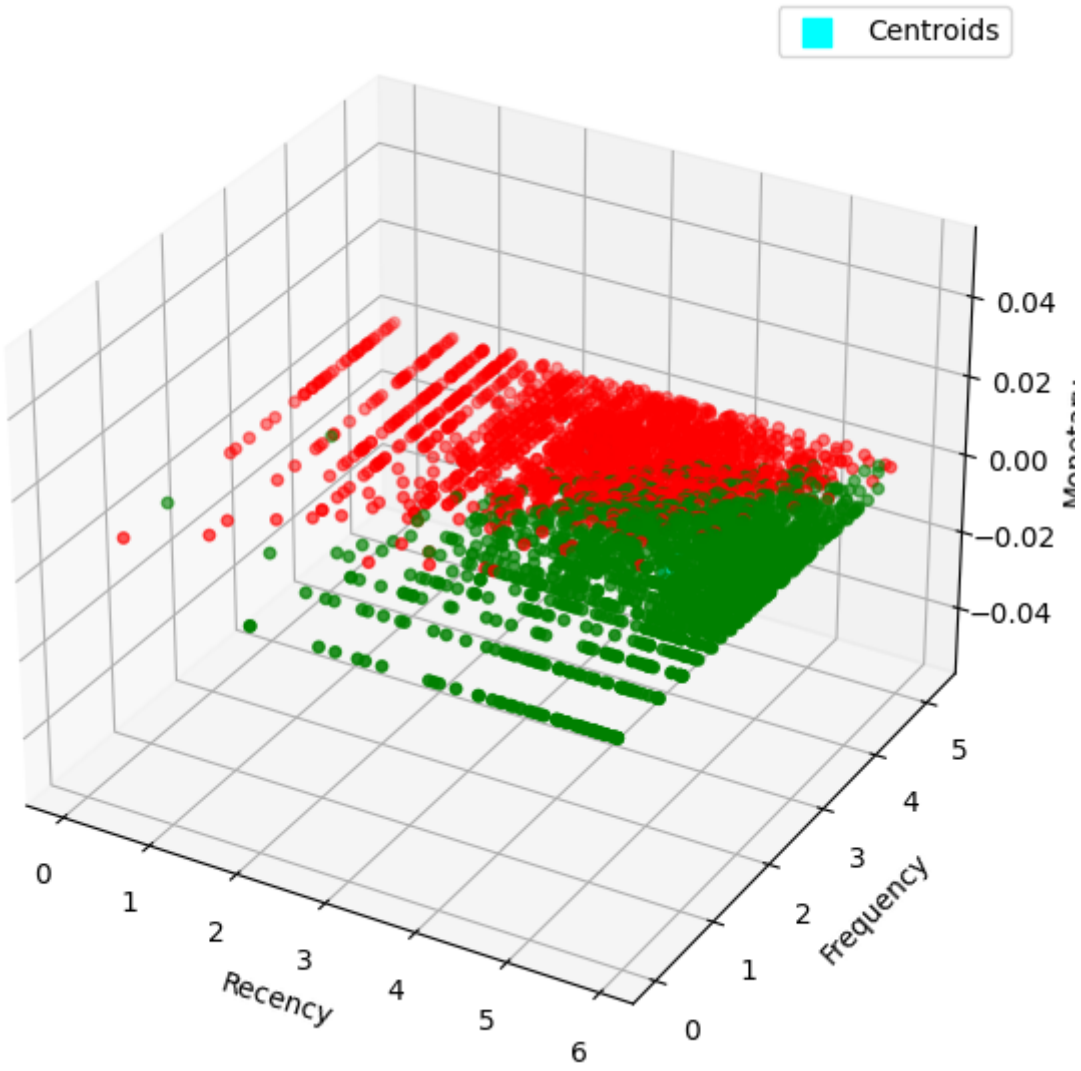
Out[35]:
```
<matplotlib.legend.Legend at 0x287159bd0>
```



In [36]:
```
km.cluster_centers_
```

Out[36]:
```
array([[3.07154533, 4.11023779, 6.87298137],
       [4.84185908, 2.66150382, 5.51540887]])
```

In [37]:
```
import matplotlib
fig=plt.figure(figsize=(9,7))
ax=fig.add_subplot(111,projection='3d')
xs=X[:,0]
ys=X[:,1]
# zs=X[:,2]
colors = ['red', 'blue', 'green']
ax.scatter(xs,ys,s=15,c=df_rfm['label'],cmap=matplotlib.colors.ListedColormap(c
ax.scatter(km.cluster_centers_[:, 0], km.cluster_centers_[:, 1], color = 'cyan'
           label = 'Centroids', s=100, alpha=1)
ax.set_xlabel('Recency')
ax.set_ylabel('Frequency')
ax.set_zlabel('Monetary')
plt.legend()
plt.show()
```



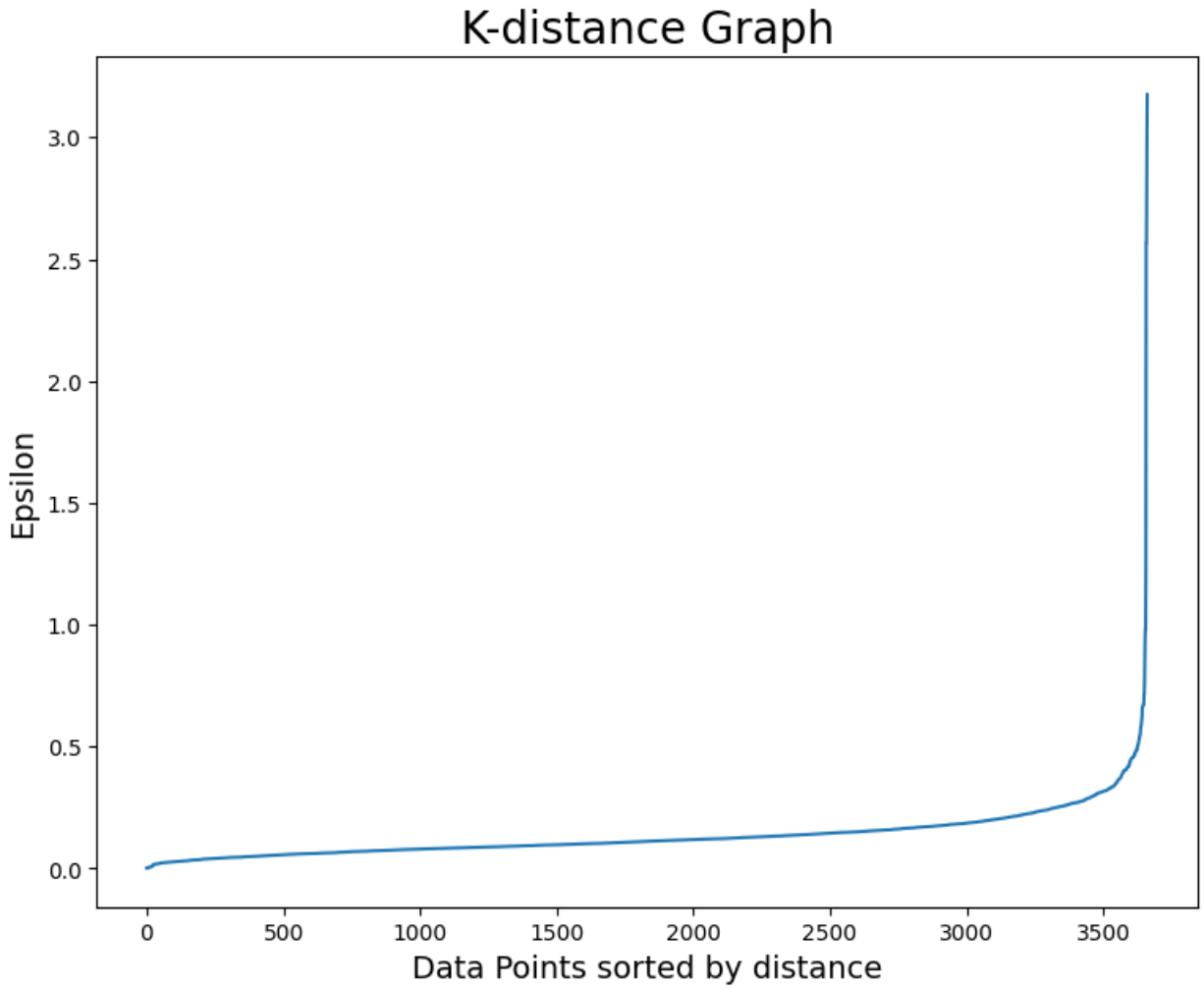
In [38]:
```
silhouette_km = silhouette_score(rfm_scaled, y)
silhouette_km
```

Out[38]: 0.36209091100617175

DBSCAN

In [39]:
```
from sklearn.neighbors import NearestNeighbors
neigh = NearestNeighbors(n_neighbors=2)
nbrs = neigh.fit(df_rfm[['Recency_log', 'Monetary_log', 'Frequency_log']])
distances, indices = nbrs.kneighbors(df_rfm[['Recency_log', 'Monetary_log', 'Fr
```

In [40]:
```
# Plotting K-distance Graph
distances = np.sort(distances, axis=0)
distances_new = distances[:,1]
plt.figure(figsize=(9, 7))
plt.plot(distances_new)
plt.title('K-distance Graph',fontsize=20)
plt.xlabel('Data Points sorted by distance',fontsize=14)
plt.ylabel('Epsilon',fontsize=14)
plt.show()
```



In [41]:
```
from sklearn.cluster import DBSCAN

dbsc_times = []

for i in range(100):
    st = timeit.default_timer()
    dbscan_opt=DBSCAN(eps=0.5,min_samples=6)
    dbscan_opt.fit(df_rfm[['Recency_log', 'Monetary_log', 'Frequency_log']])
    dbsc_times.append(timeit.default_timer() - st)

db_time = np.mean(dbsc_times)
db_time
```

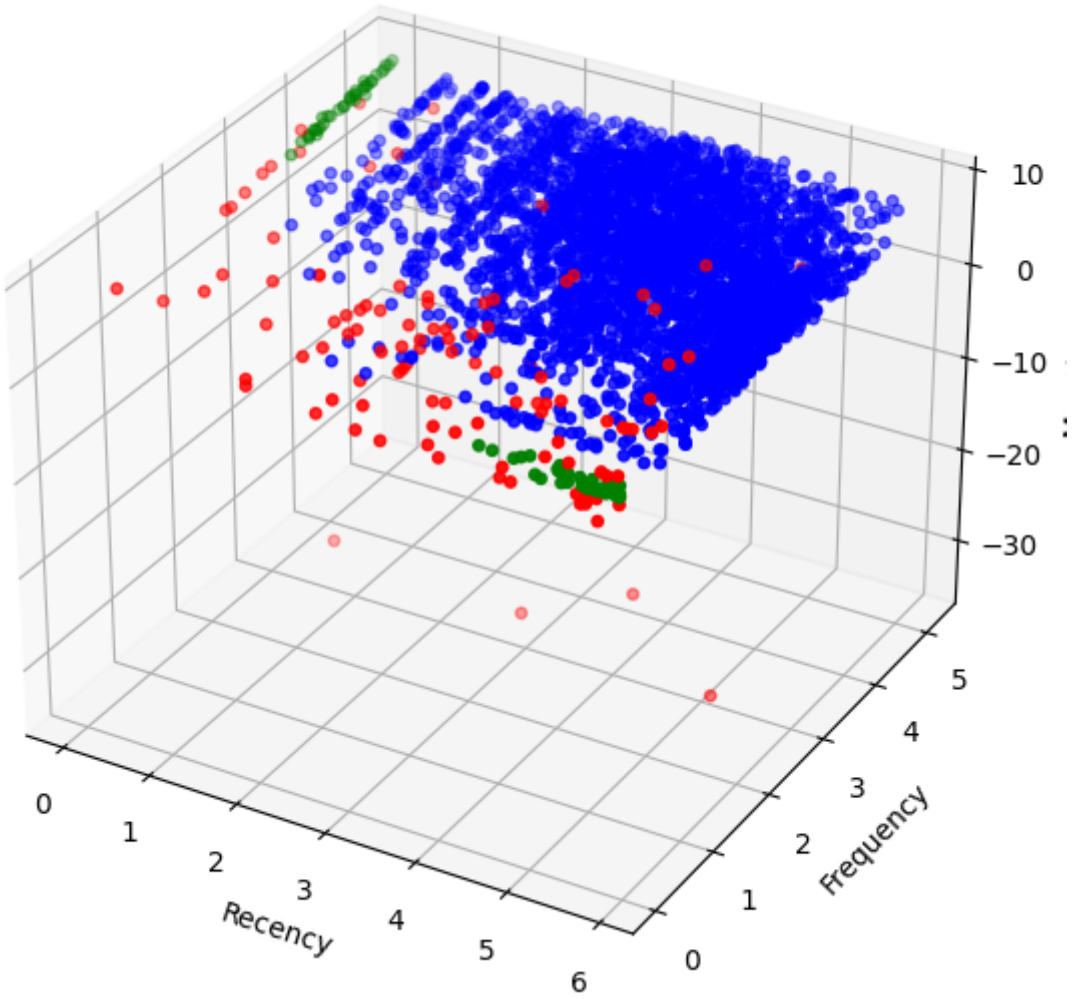
Out[41]:
```
0.018749717140308347
```

In [42]:
```
df_rfm['DBSCAN_opt_labels']=dbscan_opt.labels_
df_rfm['DBSCAN_opt_labels'].value_counts()
```

Out[42]:
```
 0    3481
-1     112
 1      38
 2      31
Name: DBSCAN_opt_labels, dtype: int64
```

In [43]:
```
fig=plt.figure(figsize=(9,7))
```

```
ax=fig.add_subplot(111,projection='3d')
xs=df_rfm.Recency_log
ys=df_rfm.Frequency_log
zs=df_rfm.Monetary_log
# xs, ys, zs = X_scaled[:,0], X_scaled[:,1], X_scaled[:,2]
ax.scatter(xs,ys,zs,s=15,c=df_rfm['DBSCAN_opt_labels'],cmap=matplotlib.colors.L
ax.set_xlabel('Recency')
ax.set_ylabel('Frequency')
ax.set_zlabel('Monetary')
plt.show()
```



In [44]:
```
from sklearn import metrics

silhouette_dbsc = metrics.silhouette_score(df_rfm[['Recency_log', 'Monetary_log
silhouette_dbsc
```

Out[44]:
```
0.22757369702848815
```

In [45]:
```
df_stats = pd.DataFrame(
    [
        ['Silhouette Score', silhouette_km, silhouette_dbsc],
        ['RunTime', km_time, db_time]
    ],
```

```
    columns=['Metrics', 'K Means', 'DBSCAN']
)
```

In [46]:
```
df_stats
```

Out[46]:

	Metrics	K Means	DBSCAN
0	Silhouette Score	0.362091	0.227574
1	RunTime	0.092402	0.018750

In [47]:
```
df_stats.plot.bar(x='Metrics', rot=0)
```

Out[47]:
```
<AxesSubplot: xlabel='Metrics'>
```