Online Retail Data Clustering

February 19, 2026

1 IMPORTING THE REQUIRED LIBRARIES

[1]:

```python
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.cluster import KMeans
from sklearn.metrics import silhouette_score
from sklearn.preprocessing import StandardScaler

# Setting to make numbers easier to read on display
pd.options.display.float_format = '{:20.2f}'.format

# Show all columns on output
pd.set_option('display.max_columns', 999)
```

[2]:

```python
df = pd.read_excel("online_retail_II.xlsx", sheet_name=0)

df.head(10)
```

[2]:

```
  Invoice StockCode                          Description  Quantity  \
0  489434     85048  15CM CHRISTMAS GLASS BALL 20 LIGHTS        12
1  489434    79323P                   PINK CHERRY LIGHTS        12
2  489434    79323W                  WHITE CHERRY LIGHTS        12
3  489434     22041         RECORD FRAME 7" SINGLE SIZE         48
4  489434     21232       STRAWBERRY CERAMIC TRINKET BOX        24
5  489434     22064           PINK DOUGHNUT TRINKET POT         24
6  489434     21871                  SAVE THE PLANET MUG        24
7  489434     21523   FANCY FONT HOME SWEET HOME DOORMAT        10
8  489435     22350                            CAT BOWL         12
9  489435     22349       DOG BOWL , CHASING BALL DESIGN        12

          InvoiceDate                Price          Customer ID  \
0 2009-12-01 07:45:00                 6.95             13085.00
1 2009-12-01 07:45:00                 6.75             13085.00
2 2009-12-01 07:45:00                 6.75             13085.00
3 2009-12-01 07:45:00                 2.10             13085.00
```

```
4 2009-12-01 07:45:00                 1.25             13085.00
5 2009-12-01 07:45:00                 1.65             13085.00
6 2009-12-01 07:45:00                 1.25             13085.00
7 2009-12-01 07:45:00                 5.95             13085.00
8 2009-12-01 07:46:00                 2.55             13085.00
9 2009-12-01 07:46:00                 3.75             13085.00

          Country
0  United Kingdom
1  United Kingdom
2  United Kingdom
3  United Kingdom
4  United Kingdom
5  United Kingdom
6  United Kingdom
7  United Kingdom
8  United Kingdom
9  United Kingdom
```

2 EXPLORATORY DATA ANALYSIS

[3]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 525461 entries, 0 to 525460
Data columns (total 8 columns):
 #   Column       Non-Null Count   Dtype
---  ------       --------------   -----
 0   Invoice      525461 non-null  object
 1   StockCode    525461 non-null  object
 2   Description  522533 non-null  object
 3   Quantity     525461 non-null  int64
 4   InvoiceDate  525461 non-null  datetime64[ns]
 5   Price        525461 non-null  float64
 6   Customer ID  417534 non-null  float64
 7   Country      525461 non-null  object
dtypes: datetime64[ns](1), float64(2), int64(1), object(4)
memory usage: 32.1+ MB
```

[4]:

```
df.describe()
```

[4]:

```
                  Quantity                    InvoiceDate  \
count            525461.00                         525461
mean                 10.34  2010-06-28 11:37:36.845017856
min               -9600.00            2009-12-01 07:45:00
25%                   1.00            2010-03-21 12:20:00
50%                   3.00            2010-07-06 09:51:00
```

```
75%                  10.00            2010-10-15 12:45:00
max               19152.00            2010-12-09 20:01:00
std                 107.42                            NaN

                     Price          Customer ID
count            525461.00            417534.00
mean                  4.69             15360.65
min              -53594.36             12346.00
25%                   1.25             13983.00
50%                   2.10             15311.00
75%                   4.21             16799.00
max               25111.09             18287.00
std                 146.13              1680.81
```

```
[9]: df.describe(include="O")
```

```
[9]:
        Invoice StockCode                         Description         Country
count    525461    525461                              522533          525461
unique    28816      4632                                4681              40
top      537434    85123A  WHITE HANGING HEART T-LIGHT HOLDER  United Kingdom
freq        675      3516                                3549          485852
```

```
[10]: df[df["Customer ID"].isna()].head(10)
```

```
[10]:
     Invoice StockCode                         Description  Quantity  \
263   489464     21733                        85123a mixed       -96
283   489463     71477                               short      -240
284   489467    85123A                         21733 mixed      -192
470   489521     21646                                 NaN       -50
577   489525    85226C           BLUE PULL BACK RACING CAR         1
578   489525     85227         SET/6 3D KIT CARDS FOR KIDS         1
1055  489548     22271                FELTCRAFT DOLL ROSIE         1
1056  489548     22254                FELT TOADSTOOL LARGE        12
1057  489548     22273                FELTCRAFT DOLL MOLLY         3
1058  489548     22195        LARGE HEART MEASURING SPOONS         1

             InvoiceDate                Price  Customer ID         Country
263  2009-12-01 10:52:00                 0.00          NaN  United Kingdom
283  2009-12-01 10:52:00                 0.00          NaN  United Kingdom
284  2009-12-01 10:53:00                 0.00          NaN  United Kingdom
470  2009-12-01 11:44:00                 0.00          NaN  United Kingdom
577  2009-12-01 11:49:00                 0.55          NaN  United Kingdom
578  2009-12-01 11:49:00                 0.85          NaN  United Kingdom
1055 2009-12-01 12:32:00                 2.95          NaN  United Kingdom
1056 2009-12-01 12:32:00                 1.25          NaN  United Kingdom
1057 2009-12-01 12:32:00                 2.95          NaN  United Kingdom
1058 2009-12-01 12:32:00                 1.65          NaN  United Kingdom
```

```
[11]: df[df["Quantity"]<0].head(10)
```

```
[11]:      Invoice StockCode                        Description  Quantity  \
      178  C489449     22087           PAPER BUNTING WHITE LACE       -12
      179  C489449    85206A       CREAM FELT EASTER EGG BASKET        -6
      180  C489449     21895      POTTING SHED SOW 'N' GROW SET        -4
      181  C489449     21896                 POTTING SHED TWINE        -6
      182  C489449     22083         PAPER CHAIN KIT RETRO SPOT       -12
      183  C489449     21871                SAVE THE PLANET MUG       -12
      184  C489449     84946    ANTIQUE SILVER TEA GLASS ETCHED       -12
      185  C489449    84970S  HANGING HEART ZINC T-LIGHT HOLDER       -24
      186  C489449     22090          PAPER BUNTING RETRO SPOTS       -12
      196  C489459    90200A         PURPLE SWEETHEART BRACELET        -3

                  InvoiceDate                Price          Customer ID  \
      178 2009-12-01 10:33:00                 2.95             16321.00
      179 2009-12-01 10:33:00                 1.65             16321.00
      180 2009-12-01 10:33:00                 4.25             16321.00
      181 2009-12-01 10:33:00                 2.10             16321.00
      182 2009-12-01 10:33:00                 2.95             16321.00
      183 2009-12-01 10:33:00                 1.25             16321.00
      184 2009-12-01 10:33:00                 1.25             16321.00
      185 2009-12-01 10:33:00                 0.85             16321.00
      186 2009-12-01 10:33:00                 2.95             16321.00
      196 2009-12-01 10:44:00                 4.25             17592.00

                  Country
      178       Australia
      179       Australia
      180       Australia
      181       Australia
      182       Australia
      183       Australia
      184       Australia
      185       Australia
      186       Australia
      196  United Kingdom
```

```
[13]: df["Invoice"]=df["Invoice"].astype("str")
      df[df["Invoice"].str.match("\\d{6}$") == False]
```

```
[13]:         Invoice StockCode                       Description  Quantity  \
      178     C489449     22087          PAPER BUNTING WHITE LACE       -12
      179     C489449    85206A      CREAM FELT EASTER EGG BASKET        -6
      180     C489449     21895     POTTING SHED SOW 'N' GROW SET        -4
      181     C489449     21896                POTTING SHED TWINE        -6
      182     C489449     22083        PAPER CHAIN KIT RETRO SPOT       -12
```

```
…         …       …                               …       …
524695  C538123     22956          36 FOIL HEART CAKE CASES        -2
524696  C538124         M                            Manual        -4
524697  C538124     22699  ROSES REGENCY TEACUP AND SAUCER         -1
524698  C538124     22423          REGENCY CAKESTAND 3 TIER        -1
525282  C538164    35004B       SET OF 3 BLACK FLYING DUCKS        -1

               InvoiceDate                Price          Customer ID  \
178     2009-12-01 10:33:00                2.95             16321.00
179     2009-12-01 10:33:00                1.65             16321.00
180     2009-12-01 10:33:00                4.25             16321.00
181     2009-12-01 10:33:00                2.10             16321.00
182     2009-12-01 10:33:00                2.95             16321.00
…                    …                  …                  …
524695 2010-12-09 15:41:00                2.10             12605.00
524696 2010-12-09 15:43:00                0.50             15329.00
524697 2010-12-09 15:43:00                2.95             15329.00
524698 2010-12-09 15:43:00               12.75             15329.00
525282 2010-12-09 17:32:00                1.95             14031.00

               Country
178          Australia
179          Australia
180          Australia
181          Australia
182          Australia
…                 …
524695         Germany
524696  United Kingdom
524697  United Kingdom
524698  United Kingdom
525282  United Kingdom

[10209 rows x 8 columns]
```

[14]:

```
df["Invoice"].str.replace("[0-9]","",regex=True).unique()
```

[14]:

```
array(['', 'C', 'A'], dtype=object)
```

[16]:

```
df[df["Invoice"].str.startswith("A")]
```

[16]:

```
        Invoice StockCode      Description  Quantity         InvoiceDate  \
179403  A506401         B  Adjust bad debt         1 2010-04-29 13:36:00
276274  A516228         B  Adjust bad debt         1 2010-07-19 11:24:00
403472  A528059         B  Adjust bad debt         1 2010-10-20 12:04:00

                      Price  Customer ID         Country
```

```
179403              -53594.36          NaN  United Kingdom
276274              -44031.79          NaN  United Kingdom
403472              -38925.87          NaN  United Kingdom
```

```
[21]: df["StockCode"]=df["StockCode"].astype("str")
      df[(df["StockCode"].str.match("^\\d{5}$") == False) & (df["StockCode"].str.
       ↪match("^\\d{5}[a-zA-Z]+$") == False)]["StockCode"].unique()
```

```
[21]: array(['POST', 'D', 'DCGS0058', 'DCGS0068', 'DOT', 'M', 'DCGS0004',
             'DCGS0076', 'C2', 'BANK CHARGES', 'DCGS0003', 'TEST001',
             'gift_0001_80', 'DCGS0072', 'gift_0001_20', 'DCGS0044', 'TEST002',
             'gift_0001_10', 'gift_0001_50', 'DCGS0066N', 'gift_0001_30',
             'PADS', 'ADJUST', 'gift_0001_40', 'gift_0001_60', 'gift_0001_70',
             'gift_0001_90', 'DCGSSGIRL', 'DCGS0006', 'DCGS0016', 'DCGS0027',
             'DCGS0036', 'DCGS0039', 'DCGS0060', 'DCGS0056', 'DCGS0059', 'GIFT',
             'DCGSLBOY', 'm', 'DCGS0053', 'DCGS0062', 'DCGS0037', 'DCGSSBOY',
             'DCGSLGIRL', 'S', 'DCGS0069', 'DCGS0070', 'DCGS0075', 'B',
             'DCGS0041', 'ADJUST2', '47503J ', 'C3', 'SP1002', 'AMAZONFEE'],
            dtype=object)
```

```
[22]: df[df["StockCode"].str.contains("^DOT")]
```

```
[22]:        Invoice StockCode     Description  Quantity          InvoiceDate  \
      2379    489597       DOT  DOTCOM POSTAGE         1 2009-12-01 14:28:00
      2539    489600       DOT  DOTCOM POSTAGE         1 2009-12-01 14:43:00
      2551    489601       DOT  DOTCOM POSTAGE         1 2009-12-01 14:44:00
      2571    489602       DOT  DOTCOM POSTAGE         1 2009-12-01 14:45:00
      2619    489603       DOT  DOTCOM POSTAGE         1 2009-12-01 14:46:00
      …          …       …            …     …                  …
      524272  538071       DOT  DOTCOM POSTAGE         1 2010-12-09 14:09:00
      524887  538148       DOT  DOTCOM POSTAGE         1 2010-12-09 16:26:00
      525000  538149       DOT  DOTCOM POSTAGE         1 2010-12-09 16:27:00
      525126  538153       DOT  DOTCOM POSTAGE         1 2010-12-09 16:31:00
      525147  538154       DOT  DOTCOM POSTAGE         1 2010-12-09 16:35:00

                       Price  Customer ID         Country
      2379            647.19          NaN  United Kingdom
      2539             55.96          NaN  United Kingdom
      2551             68.39          NaN  United Kingdom
      2571             59.35          NaN  United Kingdom
      2619             42.39          NaN  United Kingdom
      …                  …          …             …
      524272          885.94          NaN  United Kingdom
      524887          547.32          NaN  United Kingdom
      525000          620.68          NaN  United Kingdom
      525126          822.94          NaN  United Kingdom
      525147           85.79          NaN  United Kingdom
```

```
[736 rows x 8 columns]
```

3 DATA CLEANING

[23]:
```python
cleaned_df = df.copy()
```

[24]:
```python
cleaned_df["Invoice"]= cleaned_df["Invoice"].astype("str")
mask = (
    cleaned_df["Invoice"].str.match("^\\d{6}$")==True
)
cleaned_df = cleaned_df[mask]
cleaned_df
```

[24]:
```
       Invoice StockCode                          Description  Quantity  \
0       489434     85048  15CM CHRISTMAS GLASS BALL 20 LIGHTS        12
1       489434    79323P                   PINK CHERRY LIGHTS        12
2       489434    79323W                  WHITE CHERRY LIGHTS        12
3       489434     22041         RECORD FRAME 7" SINGLE SIZE         48
4       489434     21232       STRAWBERRY CERAMIC TRINKET BOX        24
…          …        …                                    …        …
525456  538171     22271                  FELTCRAFT DOLL ROSIE         2
525457  538171     22750          FELTCRAFT PRINCESS LOLA DOLL         1
525458  538171     22751        FELTCRAFT PRINCESS OLIVIA DOLL         1
525459  538171     20970    PINK FLORAL FELTCRAFT SHOULDER BAG         2
525460  538171     21931                JUMBO STORAGE BAG SUKI         2

               InvoiceDate                Price          Customer ID  \
0      2009-12-01 07:45:00                 6.95             13085.00
1      2009-12-01 07:45:00                 6.75             13085.00
2      2009-12-01 07:45:00                 6.75             13085.00
3      2009-12-01 07:45:00                 2.10             13085.00
4      2009-12-01 07:45:00                 1.25             13085.00
…                        …                  …                  …
525456 2010-12-09 20:01:00                 2.95             17530.00
525457 2010-12-09 20:01:00                 3.75             17530.00
525458 2010-12-09 20:01:00                 3.75             17530.00
525459 2010-12-09 20:01:00                 3.75             17530.00
525460 2010-12-09 20:01:00                 1.95             17530.00

               Country
0       United Kingdom
1       United Kingdom
2       United Kingdom
3       United Kingdom
4       United Kingdom
…                 …
```

```
525456  United Kingdom
525457  United Kingdom
525458  United Kingdom
525459  United Kingdom
525460  United Kingdom

[515252 rows x 8 columns]
```

[26]:

```
cleaned_df["StockCode"]= cleaned_df["StockCode"].astype("str")
mask = (
    (cleaned_df["StockCode"].str.match("^\\d{5}$")==True)
    | (cleaned_df["StockCode"].str.match("^\\d{5}[a-zA-Z]+$")==True)
    | (cleaned_df["StockCode"].str.match("^PADS$") == True)
)

cleaned_df = cleaned_df[mask]
cleaned_df
```

```
C:\Users\udayd\AppData\Local\Temp\ipykernel_8468\3378931196.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
  cleaned_df["StockCode"]= cleaned_df["StockCode"].astype("str")
```

[26]:

```
       Invoice StockCode                          Description  Quantity  \
0       489434     85048  15CM CHRISTMAS GLASS BALL 20 LIGHTS        12
1       489434    79323P                   PINK CHERRY LIGHTS        12
2       489434    79323W                  WHITE CHERRY LIGHTS        12
3       489434     22041         RECORD FRAME 7" SINGLE SIZE         48
4       489434     21232       STRAWBERRY CERAMIC TRINKET BOX        24
…          …       …                                    …       …
525456  538171     22271                  FELTCRAFT DOLL ROSIE         2
525457  538171     22750         FELTCRAFT PRINCESS LOLA DOLL         1
525458  538171     22751       FELTCRAFT PRINCESS OLIVIA DOLL         1
525459  538171     20970   PINK FLORAL FELTCRAFT SHOULDER BAG         2
525460  538171     21931               JUMBO STORAGE BAG SUKI         2

               InvoiceDate                Price          Customer ID  \
0      2009-12-01 07:45:00                 6.95             13085.00
1      2009-12-01 07:45:00                 6.75             13085.00
2      2009-12-01 07:45:00                 6.75             13085.00
3      2009-12-01 07:45:00                 2.10             13085.00
4      2009-12-01 07:45:00                 1.25             13085.00
…                        …                  …                  …
525456 2010-12-09 20:01:00                 2.95             17530.00
```

```
525457 2010-12-09 20:01:00                 3.75             17530.00
525458 2010-12-09 20:01:00                 3.75             17530.00
525459 2010-12-09 20:01:00                 3.75             17530.00
525460 2010-12-09 20:01:00                 1.95             17530.00

               Country
0       United Kingdom
1       United Kingdom
2       United Kingdom
3       United Kingdom
4       United Kingdom
…                 …
525456  United Kingdom
525457  United Kingdom
525458  United Kingdom
525459  United Kingdom
525460  United Kingdom

[512796 rows x 8 columns]
```

[28]:

```
cleaned_df.dropna(subset = ["Customer ID"],inplace = True)
```

```
C:\Users\udayd\AppData\Local\Temp\ipykernel_8468\2119709935.py:1:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  cleaned_df.dropna(subset = ["Customer ID"],inplace = True)
```

[29]:

```
cleaned_df.describe()
```

[29]:

```
                  Quantity                    InvoiceDate  \
count            406337.00                         406337
mean                 13.62  2010-07-01 10:11:06.543288320
min                   1.00            2009-12-01 07:45:00
25%                   2.00            2010-03-26 14:01:00
50%                   5.00            2010-07-09 15:48:00
75%                  12.00            2010-10-14 17:09:00
max               19152.00            2010-12-09 20:01:00
std                  97.00                            NaN

                     Price  Customer ID
count            406337.00    406337.00
mean                  2.99     15373.63
min                   0.00     12346.00
25%                   1.25     14004.00
50%                   1.95     15326.00
```

```
75%                      3.75              16814.00
max                    295.00              18287.00
std                      4.29               1677.37
```

[31]:
```
len(cleaned_df[cleaned_df["Price"] == 0])
```

[31]:
```
28
```

[34]:
```
cleaned_df = cleaned_df[cleaned_df["Price"]> 0.0]
```

[35]:
```
cleaned_df.describe()
```

[35]:
```
                  Quantity                    InvoiceDate  \
count            406309.00                         406309
mean                 13.62  2010-07-01 10:14:25.869572352
min                   1.00            2009-12-01 07:45:00
25%                   2.00            2010-03-26 14:01:00
50%                   5.00            2010-07-09 15:48:00
75%                  12.00            2010-10-14 17:09:00
max               19152.00            2010-12-09 20:01:00
std                  97.00                            NaN

                     Price           Customer ID
count            406309.00             406309.00
mean                  2.99              15373.72
min                   0.00              12346.00
25%                   1.25              14006.00
50%                   1.95              15326.00
75%                   3.75              16814.00
max                 295.00              18287.00
std                   4.29               1677.33
```

[36]:
```
cleaned_df["Price"].min()
```

[36]:
```
0.001
```

[37]:
```
len(cleaned_df)/len(df)
```

[37]:
```
0.7732429238325965
```

Dropped about 23% of records.

4 FEATURE ENGINEERING

[38]:
```
cleaned_df["SalesLineTotal"] = cleaned_df["Quantity"] * cleaned_df["Price"]

cleaned_df
```

[38]:

```
       Invoice StockCode                          Description  Quantity  \
0       489434     85048  15CM CHRISTMAS GLASS BALL 20 LIGHTS        12
1       489434    79323P                   PINK CHERRY LIGHTS        12
2       489434    79323W                  WHITE CHERRY LIGHTS        12
3       489434     22041         RECORD FRAME 7" SINGLE SIZE         48
4       489434     21232       STRAWBERRY CERAMIC TRINKET BOX        24
…        …       …                                  …       …
525456  538171     22271                 FELTCRAFT DOLL ROSIE         2
525457  538171     22750         FELTCRAFT PRINCESS LOLA DOLL         1
525458  538171     22751       FELTCRAFT PRINCESS OLIVIA DOLL         1
525459  538171     20970   PINK FLORAL FELTCRAFT SHOULDER BAG         2
525460  538171     21931               JUMBO STORAGE BAG SUKI         2

               InvoiceDate                Price         Customer ID  \
0       2009-12-01 07:45:00                 6.95            13085.00
1       2009-12-01 07:45:00                 6.75            13085.00
2       2009-12-01 07:45:00                 6.75            13085.00
3       2009-12-01 07:45:00                 2.10            13085.00
4       2009-12-01 07:45:00                 1.25            13085.00
…                    …                  …                  …
525456 2010-12-09 20:01:00                 2.95            17530.00
525457 2010-12-09 20:01:00                 3.75            17530.00
525458 2010-12-09 20:01:00                 3.75            17530.00
525459 2010-12-09 20:01:00                 3.75            17530.00
525460 2010-12-09 20:01:00                 1.95            17530.00

               Country       SalesLineTotal
0       United Kingdom                83.40
1       United Kingdom                81.00
2       United Kingdom                81.00
3       United Kingdom               100.80
4       United Kingdom                30.00
…                …                  …
525456  United Kingdom                 5.90
525457  United Kingdom                 3.75
525458  United Kingdom                 3.75
525459  United Kingdom                 7.50
525460  United Kingdom                 3.90

[406309 rows x 9 columns]
```

[39]:

```
aggregated_df = cleaned_df.groupby(by="Customer ID", as_index=False) \
    .agg(
        MonetaryValue=("SalesLineTotal", "sum"),
        Frequency=("Invoice", "nunique"),
        LastInvoiceDate=("InvoiceDate", "max")
    )
```

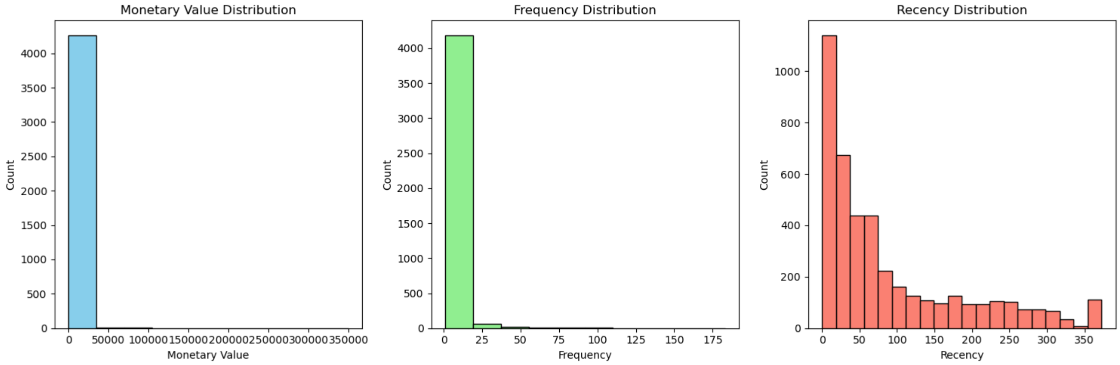
```
aggregated_df.head(5)
```

[39]:
```
           Customer ID     MonetaryValue  Frequency     LastInvoiceDate
0             12346.00            169.36          2 2010-06-28 13:53:00
1             12347.00           1323.32          2 2010-12-07 14:57:00
2             12348.00            221.16          1 2010-09-27 14:59:00
3             12349.00           2221.14          2 2010-10-28 08:23:00
4             12351.00            300.93          1 2010-11-29 15:23:00
```

[40]:
```
max_invoice_date = aggregated_df["LastInvoiceDate"].max()

aggregated_df["Recency"] = (max_invoice_date -␣
 ↪aggregated_df["LastInvoiceDate"]).dt.days

aggregated_df.head(5)
```

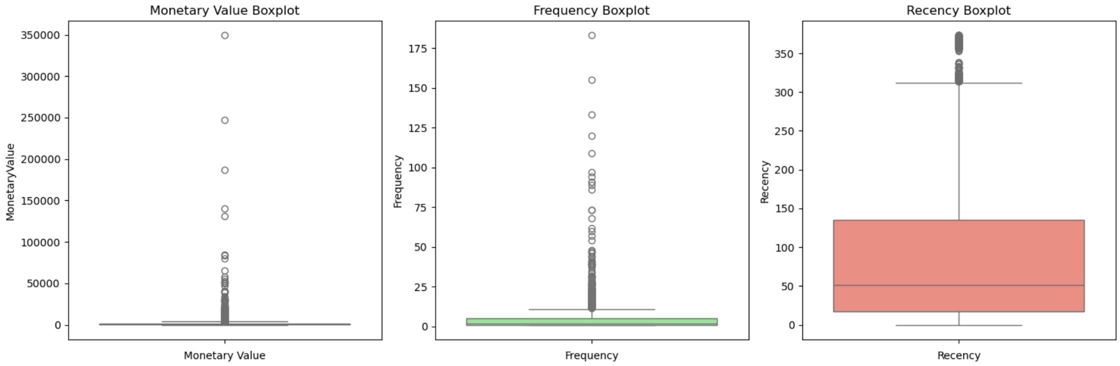
[40]:
```
           Customer ID     MonetaryValue  Frequency     LastInvoiceDate  \
0             12346.00            169.36          2 2010-06-28 13:53:00
1             12347.00           1323.32          2 2010-12-07 14:57:00
2             12348.00            221.16          1 2010-09-27 14:59:00
3             12349.00           2221.14          2 2010-10-28 08:23:00
4             12351.00            300.93          1 2010-11-29 15:23:00

   Recency
0      164
1        2
2       73
3       42
4       10
```

[41]:
```
plt.figure(figsize=(15, 5))

plt.subplot(1, 3, 1)
plt.hist(aggregated_df['MonetaryValue'], bins=10, color='skyblue',␣
 ↪edgecolor='black')
plt.title('Monetary Value Distribution')
plt.xlabel('Monetary Value')
plt.ylabel('Count')

plt.subplot(1, 3, 2)
plt.hist(aggregated_df['Frequency'], bins=10, color='lightgreen',␣
 ↪edgecolor='black')
plt.title('Frequency Distribution')
plt.xlabel('Frequency')
plt.ylabel('Count')
plt.subplot(1, 3, 3)
plt.hist(aggregated_df['Recency'], bins=20, color='salmon', edgecolor='black')
plt.title('Recency Distribution')
plt.xlabel('Recency')
plt.ylabel('Count')

plt.tight_layout()
plt.show()
```



[42]:

```
plt.figure(figsize=(15, 5))

plt.subplot(1, 3, 1)
sns.boxplot(data=aggregated_df['MonetaryValue'], color='skyblue')
plt.title('Monetary Value Boxplot')
plt.xlabel('Monetary Value')

plt.subplot(1, 3, 2)
sns.boxplot(data=aggregated_df['Frequency'], color='lightgreen')
plt.title('Frequency Boxplot')
plt.xlabel('Frequency')

plt.subplot(1, 3, 3)
sns.boxplot(data=aggregated_df['Recency'], color='salmon')
plt.title('Recency Boxplot')
plt.xlabel('Recency')

plt.tight_layout()
plt.show()
```



```
[43]: M_Q1 = aggregated_df["MonetaryValue"].quantile(0.25)
      M_Q3 = aggregated_df["MonetaryValue"].quantile(0.75)
      M_IQR = M_Q3 - M_Q1

      monetary_outliers_df = aggregated_df[(aggregated_df["MonetaryValue"] > (M_Q3 +␣
       ↪1.5 * M_IQR)) | (aggregated_df["MonetaryValue"] < (M_Q1 - 1.5 * M_IQR))].
       ↪copy()

      monetary_outliers_df.describe()
```

```
[43]:                Customer ID      MonetaryValue          Frequency  \
      count               423.00             423.00             423.00
      mean              15103.04           12188.10              17.17
      min               12357.00            3802.04               1.00
      25%               13622.00            4605.94               8.00
      50%               14961.00            6191.32              12.00
      75%               16692.00           10273.24              18.00
      max               18260.00          349164.35             183.00
      std                1728.66           25830.85              19.73

                         LastInvoiceDate             Recency
      count                          423              423.00
      mean     2010-11-09 12:26:02.978723328           30.04
      min                2009-12-10 18:03:00            0.00
      25%                2010-11-08 13:17:30            3.00
      50%                2010-11-26 12:19:00           13.00
      75%                2010-12-06 10:34:30           31.00
      max                2010-12-09 19:32:00          364.00
      std                                NaN           51.54
```

```
[44]: F_Q1 = aggregated_df['Frequency'].quantile(0.25)
      F_Q3 = aggregated_df['Frequency'].quantile(0.75)
      F_IQR = F_Q3 - F_Q1
```

```
frequency_outliers_df = aggregated_df[(aggregated_df['Frequency'] > (F_Q3 + 1.5␣
 ↪* F_IQR)) | (aggregated_df['Frequency'] < (F_Q1 - 1.5 * F_IQR))].copy()

frequency_outliers_df.describe()
```

```
[44]:               Customer ID       MonetaryValue            Frequency  \
      count              279.00              279.00               279.00
      mean             15352.66            14409.71                23.81
      min              12437.00             1094.39                12.00
      25%              13800.00             4331.56                13.00
      50%              15465.00             6615.77                17.00
      75%              16828.50            11692.41                23.00
      max              18260.00           349164.35               183.00
      std               1748.43            31381.74                21.93

                           LastInvoiceDate              Recency
      count                            279               279.00
      mean   2010-11-23 11:06:20.645161216                16.09
      min              2010-05-12 16:51:00                 0.00
      25%              2010-11-20 13:14:30                 2.00
      50%              2010-12-02 10:46:00                 7.00
      75%              2010-12-07 11:08:30                19.00
      max              2010-12-09 19:32:00               211.00
      std                              NaN                26.59
```

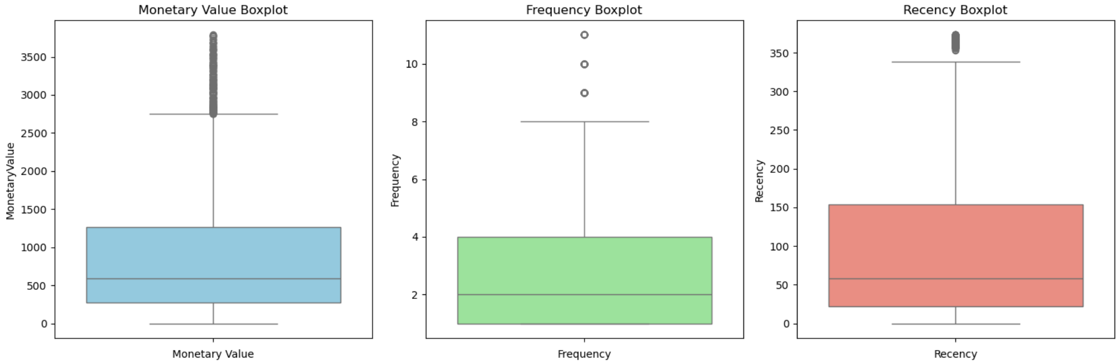
```
[47]: non_outliers_df = aggregated_df[(~aggregated_df.index.isin(monetary_outliers_df.
       ↪index)) & (~aggregated_df.index.isin(frequency_outliers_df.index))]

      non_outliers_df.describe()
```

```
[47]:               Customer ID       MonetaryValue            Frequency  \
      count             3809.00             3809.00              3809.00
      mean             15376.48              885.50                 2.86
      min              12346.00                1.55                 1.00
      25%              13912.00              279.91                 1.00
      50%              15389.00              588.05                 2.00
      75%              16854.00             1269.05                 4.00
      max              18287.00             3788.21                11.00
      std               1693.20              817.67                 2.24

                           LastInvoiceDate              Recency
      count                           3809              3809.00
      mean   2010-09-03 11:16:46.516146176                97.08
      min              2009-12-01 10:49:00                 0.00
      25%              2010-07-08 14:48:00                22.00
      50%              2010-10-12 16:25:00                58.00
      75%              2010-11-17 13:14:00               154.00
```

```
max                2010-12-09 20:01:00                373.00
std                                NaN                 98.11
```

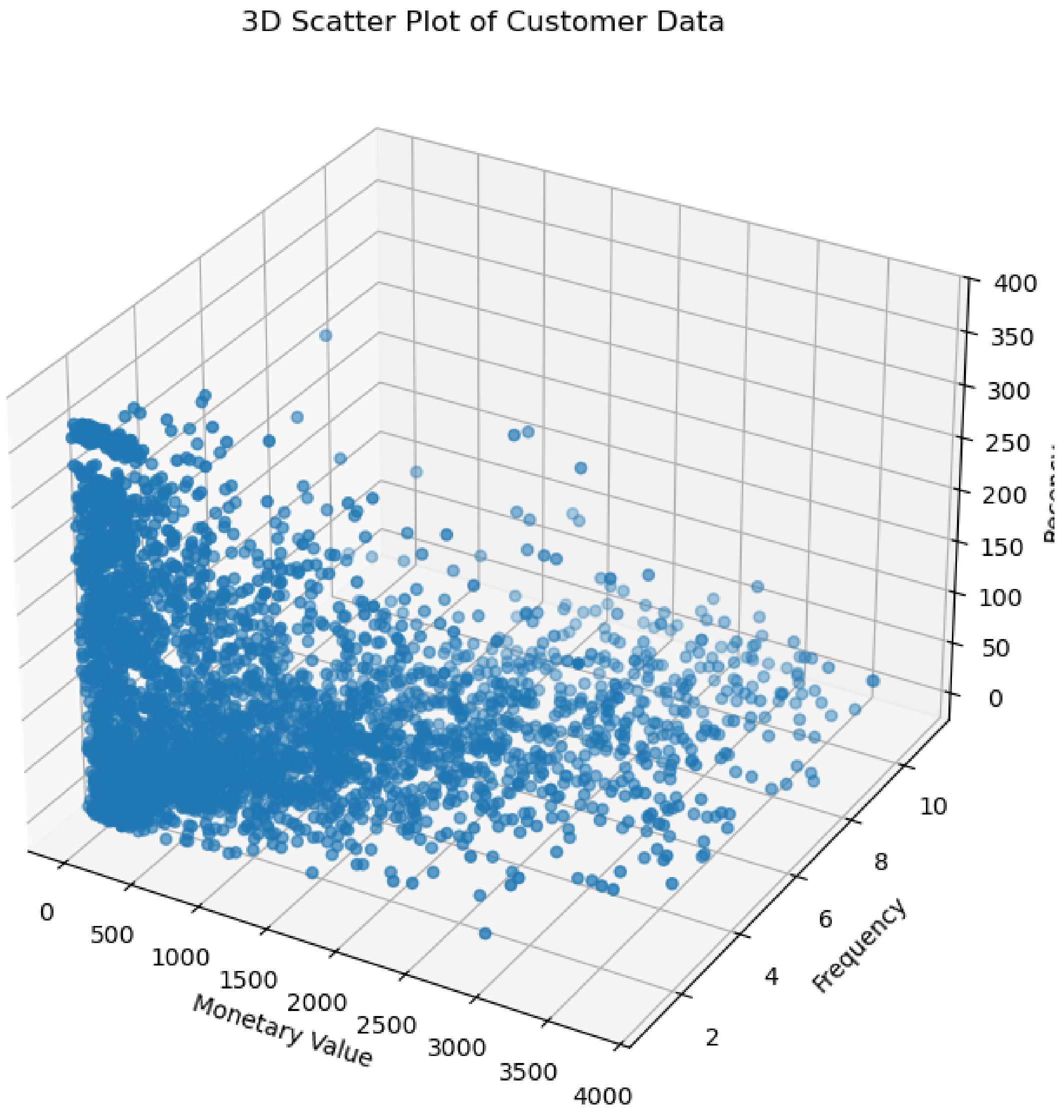
[48]:

```
plt.figure(figsize=(15, 5))

plt.subplot(1, 3, 1)
sns.boxplot(data=non_outliers_df['MonetaryValue'], color='skyblue')
plt.title('Monetary Value Boxplot')
plt.xlabel('Monetary Value')

plt.subplot(1, 3, 2)
sns.boxplot(data=non_outliers_df['Frequency'], color='lightgreen')
plt.title('Frequency Boxplot')
plt.xlabel('Frequency')

plt.subplot(1, 3, 3)
sns.boxplot(data=non_outliers_df['Recency'], color='salmon')
plt.title('Recency Boxplot')
plt.xlabel('Recency')

plt.tight_layout()
plt.show()
```



[49]:

```
fig = plt.figure(figsize=(8, 8))

ax = fig.add_subplot(projection="3d")

scatter = ax.scatter(non_outliers_df["MonetaryValue"],␣
 ↪non_outliers_df["Frequency"], non_outliers_df["Recency"])

ax.set_xlabel('Monetary Value')
ax.set_ylabel('Frequency')
ax.set_zlabel('Recency')
ax.set_title('3D Scatter Plot of Customer Data')

plt.show()
```



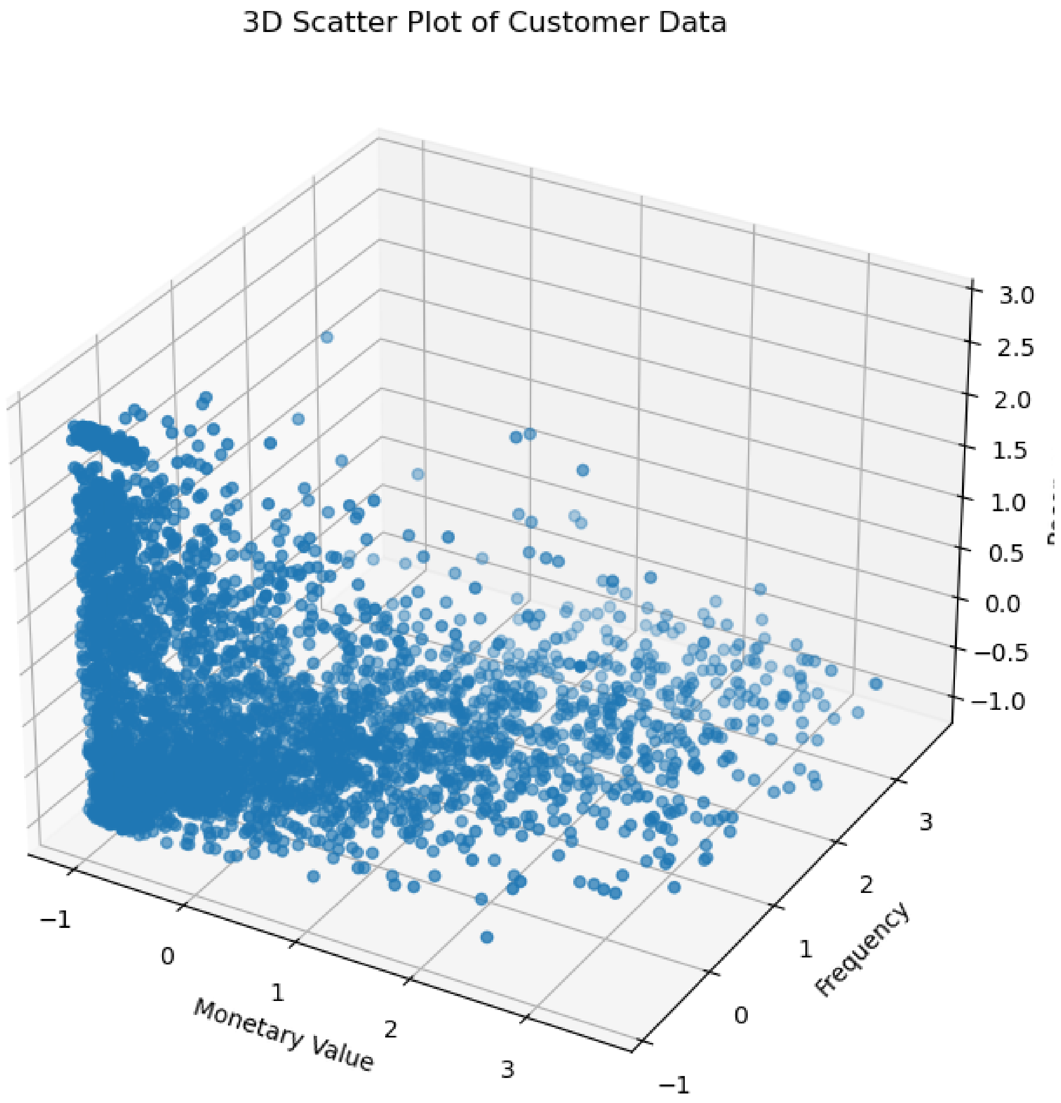
[50]:
```
scaler = StandardScaler()

scaled_data = scaler.fit_transform(non_outliers_df[["MonetaryValue",␣
 ↪"Frequency", "Recency"]])

scaled_data
```

[50]:
```
array([[-0.87594534, -0.38488934,  0.68214853],
       [ 0.5355144 , -0.38488934, -0.96925093],
       [-0.81258645, -0.83063076, -0.24548944],
       …,
       [-0.62197163, -0.83063076,  2.01753946],
       [ 0.44146683, -0.38488934,  0.14187587],
       [ 1.72488781,  0.50659348, -0.81634357]])
```

[51]:
```
scaled_data_df = pd.DataFrame(scaled_data, index=non_outliers_df.index,␣
 ↪columns=("MonetaryValue", "Frequency", "Recency"))

scaled_data_df
```

[51]:
```
            MonetaryValue          Frequency            Recency
0                   -0.88              -0.38               0.68
1                    0.54              -0.38              -0.97
2                   -0.81              -0.83              -0.25
3                    1.63              -0.38              -0.56
4                   -0.72              -0.83              -0.89
…                     …                  …                  …
4280                -0.30               1.40              -0.82
4281                -0.58              -0.83              -0.32
4282                -0.62              -0.83               2.02
4283                 0.44              -0.38               0.14
4284                 1.72               0.51              -0.82

[3809 rows x 3 columns]
```

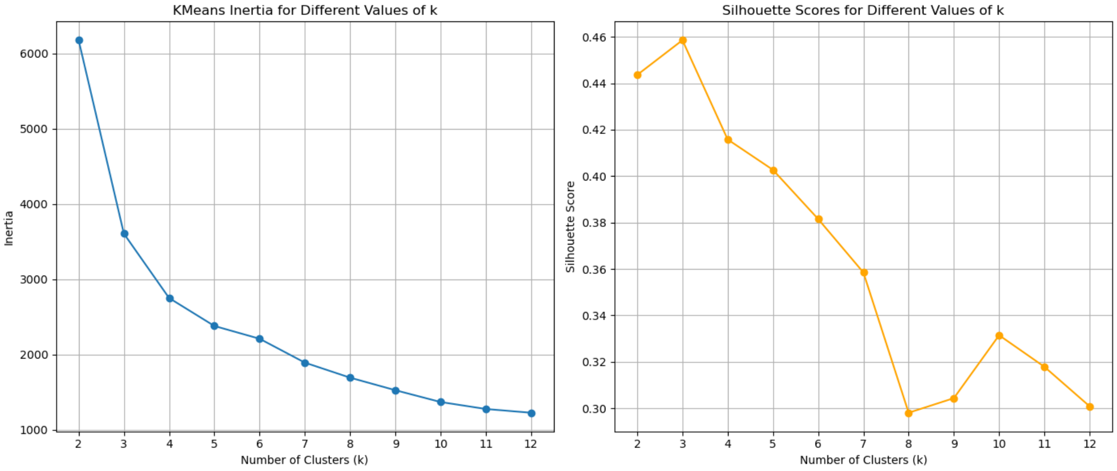
[52]:
```
fig = plt.figure(figsize=(8, 8))

ax = fig.add_subplot(projection="3d")

scatter = ax.scatter(scaled_data_df["MonetaryValue"],␣
 ↪scaled_data_df["Frequency"], scaled_data_df["Recency"])

ax.set_xlabel('Monetary Value')
ax.set_ylabel('Frequency')
ax.set_zlabel('Recency')

ax.set_title('3D Scatter Plot of Customer Data')

plt.show()
```



5 KMEANS CLUSTERING

[53]:

```
max_k = 12

inertia = []
silhoutte_scores = []
k_values = range(2, max_k + 1)

for k in k_values:

    kmeans = KMeans(n_clusters=k, random_state=42, max_iter=1000)
    cluster_labels = kmeans.fit_predict(scaled_data_df)

    sil_score = silhouette_score(scaled_data_df, cluster_labels)

    silhoutte_scores.append(sil_score)

    inertia.append(kmeans.inertia_)

plt.figure(figsize=(14, 6))

plt.subplot(1, 2, 1)
plt.plot(k_values, inertia, marker='o')
plt.title('KMeans Inertia for Different Values of k')
plt.xlabel('Number of Clusters (k)')
plt.ylabel('Inertia')
plt.xticks(k_values)
plt.grid(True)

plt.subplot(1, 2, 2)
plt.plot(k_values, silhoutte_scores, marker='o', color='orange')
plt.title('Silhouette Scores for Different Values of k')
plt.xlabel('Number of Clusters (k)')
plt.ylabel('Silhouette Score')
plt.xticks(k_values)
plt.grid(True)

plt.tight_layout()
plt.show()
```



[54]:

```
kmeans = KMeans(n_clusters=4, random_state=42, max_iter=1000)

cluster_labels = kmeans.fit_predict(scaled_data_df)

cluster_labels
```

[54]:

```
array([1, 0, 2, …, 1, 0, 0], dtype=int32)
```

[55]:

```
non_outliers_df["Cluster"] = cluster_labels

non_outliers_df
```

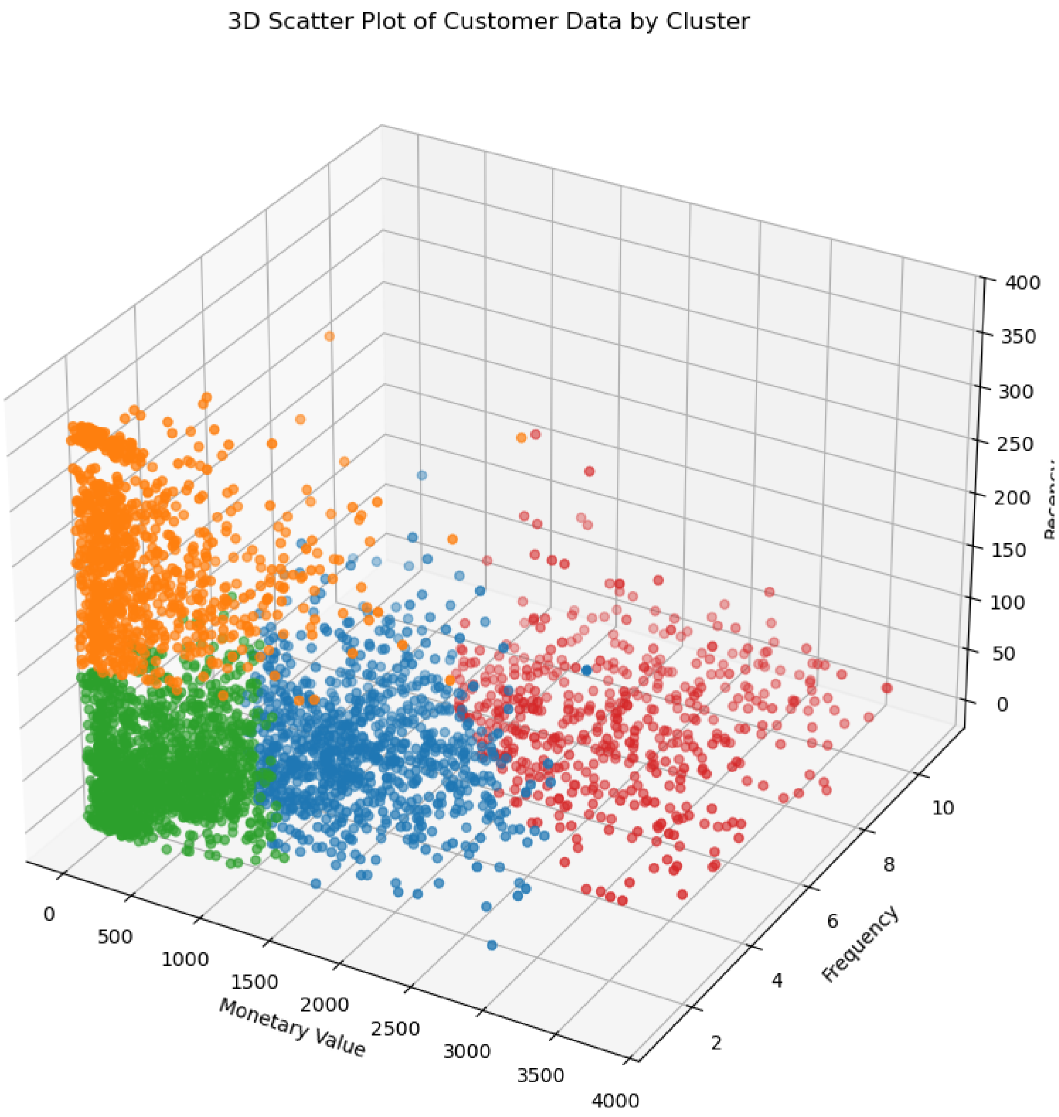
```
C:\Users\udayd\AppData\Local\Temp\ipykernel_8468\3577770544.py:1:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  non_outliers_df["Cluster"] = cluster_labels
```

[55]:

```
               Customer ID       MonetaryValue  Frequency     LastInvoiceDate  \
0                 12346.00              169.36          2 2010-06-28 13:53:00
1                 12347.00             1323.32          2 2010-12-07 14:57:00
2                 12348.00              221.16          1 2010-09-27 14:59:00
3                 12349.00             2221.14          2 2010-10-28 08:23:00
4                 12351.00              300.93          1 2010-11-29 15:23:00
…                      …                   …        …                  …
4280              18283.00              641.77          6 2010-11-22 15:30:00
4281              18284.00              411.68          1 2010-10-04 11:33:00
4282              18285.00              377.00          1 2010-02-17 10:24:00
4283              18286.00             1246.43          2 2010-08-20 11:57:00
4284              18287.00             2295.71          4 2010-11-22 11:51:00

      Recency  Cluster
0         164        1
1           2        0
2          73        2
3          42        0
4          10        2
…         …       …
4280       17        0
4281       66        2
4282      295        1
4283      111        0
4284       17        0

[3809 rows x 6 columns]
```

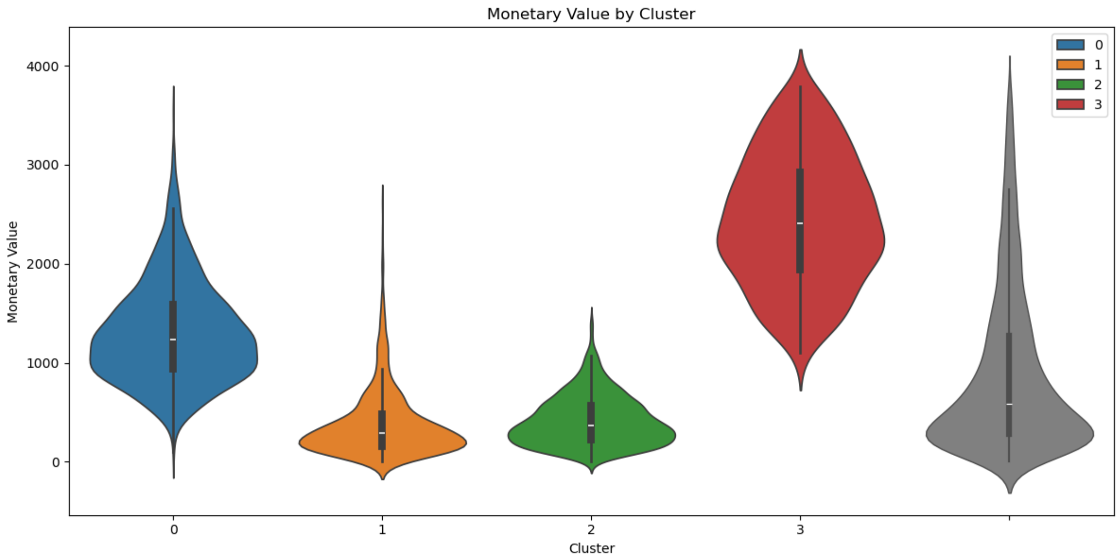
[56]:

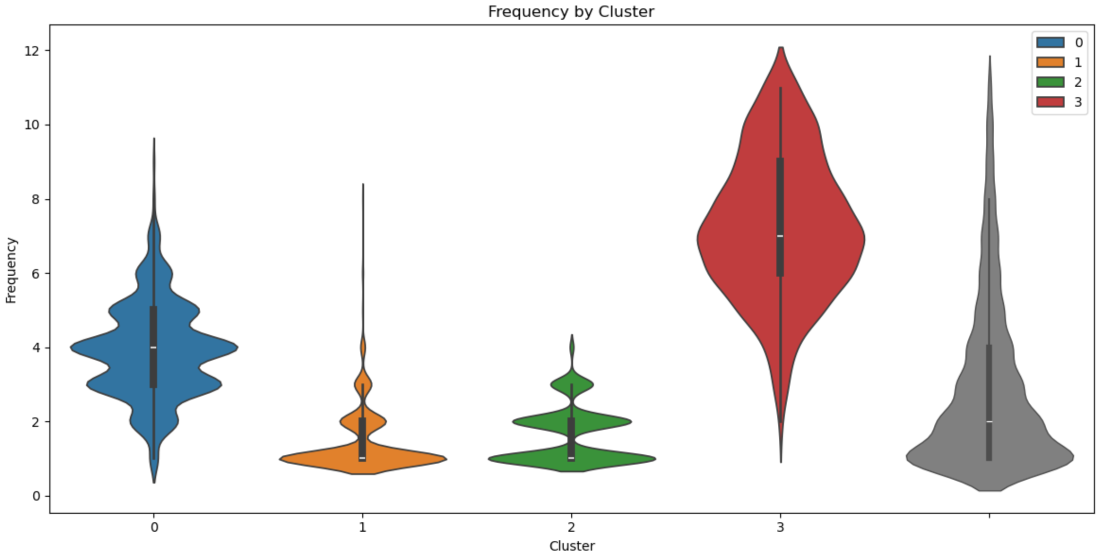
```python
cluster_colors = {0: '#1f77b4',  # Blue
                  1: '#ff7f0e',  # Orange
                  2: '#2ca02c',  # Green
                  3: '#d62728'}  # Red

colors = non_outliers_df['Cluster'].map(cluster_colors)

fig = plt.figure(figsize=(10, 10))
ax = fig.add_subplot(projection='3d')

scatter = ax.scatter(non_outliers_df['MonetaryValue'],
                     non_outliers_df['Frequency'],
                     non_outliers_df['Recency'],
                     c=colors,  # Use mapped solid colors
                     marker='o')

ax.set_xlabel('Monetary Value')
ax.set_ylabel('Frequency')
ax.set_zlabel('Recency')

ax.set_title('3D Scatter Plot of Customer Data by Cluster')

plt.show()
```

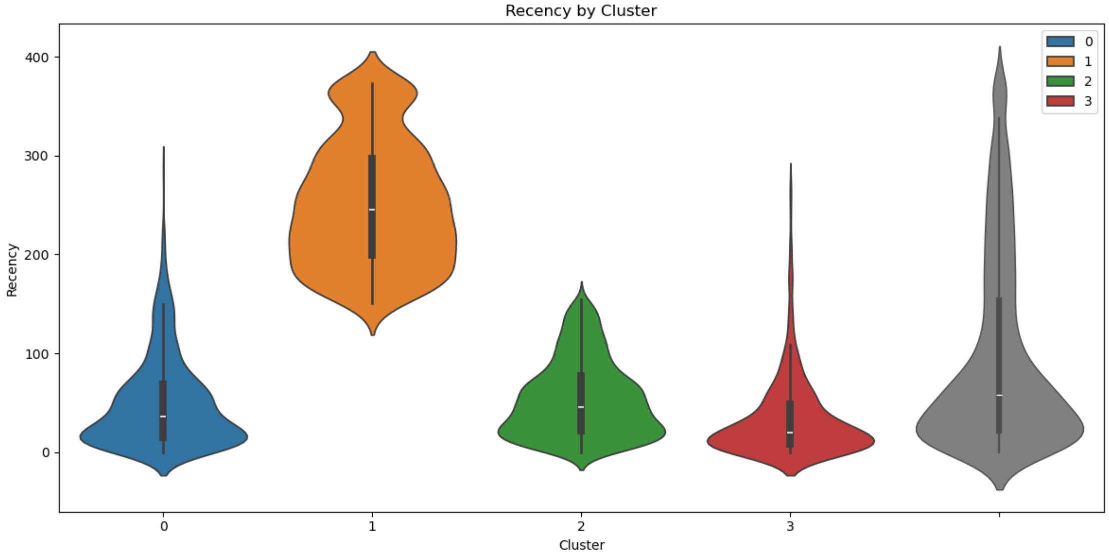


[57]:
```
plt.figure(figsize=(12, 18))

plt.subplot(3, 1, 1)
sns.violinplot(x=non_outliers_df['Cluster'],␣
 ↪y=non_outliers_df['MonetaryValue'], palette=cluster_colors,␣
 ↪hue=non_outliers_df["Cluster"])
sns.violinplot(y=non_outliers_df['MonetaryValue'], color='gray', linewidth=1.0)
plt.title('Monetary Value by Cluster')
plt.ylabel('Monetary Value')

plt.subplot(3, 1, 2)
```

```
sns.violinplot(x=non_outliers_df['Cluster'], y=non_outliers_df['Frequency'],␣
 ↪palette=cluster_colors, hue=non_outliers_df["Cluster"])
sns.violinplot(y=non_outliers_df['Frequency'], color='gray', linewidth=1.0)
plt.title('Frequency by Cluster')
plt.ylabel('Frequency')


plt.subplot(3, 1, 3)
sns.violinplot(x=non_outliers_df['Cluster'], y=non_outliers_df['Recency'],␣
 ↪palette=cluster_colors, hue=non_outliers_df["Cluster"])
sns.violinplot(y=non_outliers_df['Recency'], color='gray', linewidth=1.0)
plt.title('Recency by Cluster')
plt.ylabel('Recency')

plt.tight_layout()
plt.show()
```


Monetary Value by Cluster
Monetary Value
4000
3000
2000
1000
0
0
1
2
3
Cluster
0
1
2
3


Frequency by Cluster
Frequency
12
10
8
6
4
2
0
0
1
2
3
Cluster
0
1
2
3


Recency by Cluster
Recency
400
300
200
100
0
0
1
2
3
Cluster
0
1
2
3

[58]:

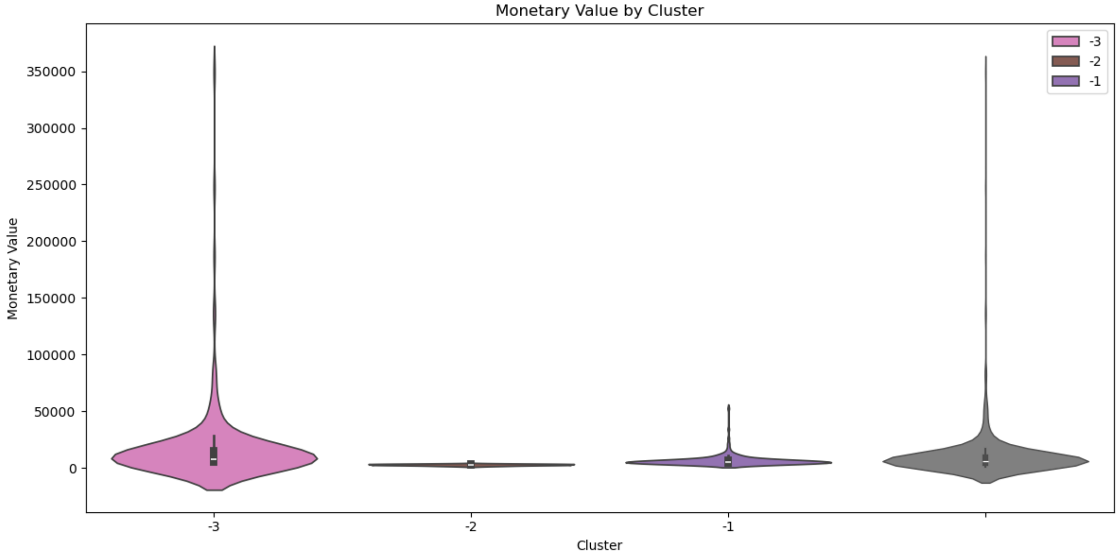
```
overlap_indices = monetary_outliers_df.index.intersection(frequency_outliers_df.
 ↪index)

monetary_only_outliers = monetary_outliers_df.drop(overlap_indices)
frequency_only_outliers = frequency_outliers_df.drop(overlap_indices)
monetary_and_frequency_outliers = monetary_outliers_df.loc[overlap_indices]

monetary_only_outliers["Cluster"] = -1
frequency_only_outliers["Cluster"] = -2
monetary_and_frequency_outliers["Cluster"] = -3

outlier_clusters_df = pd.concat([monetary_only_outliers,␣
 ↪frequency_only_outliers, monetary_and_frequency_outliers])

outlier_clusters_df
```

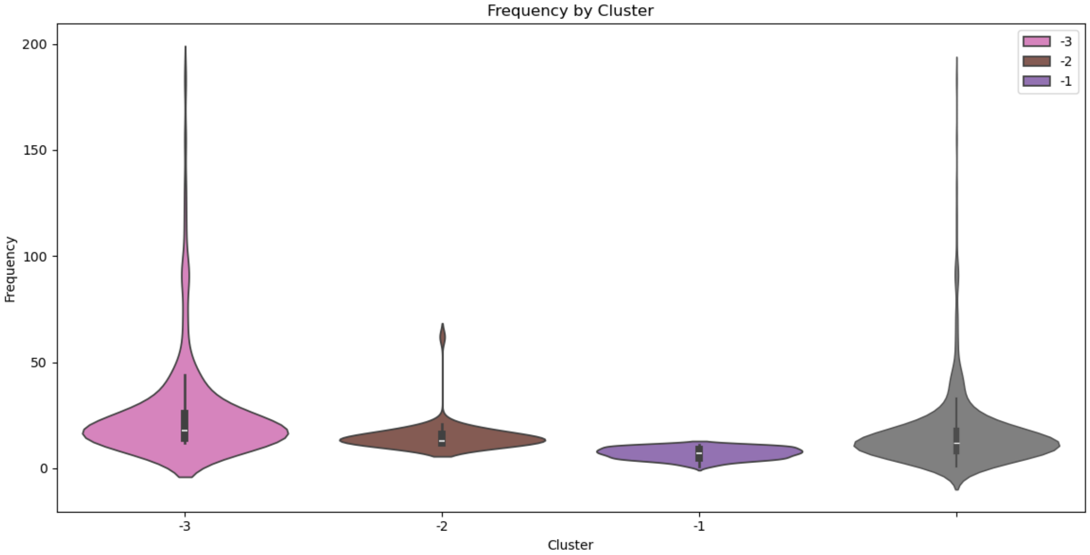
[58]:

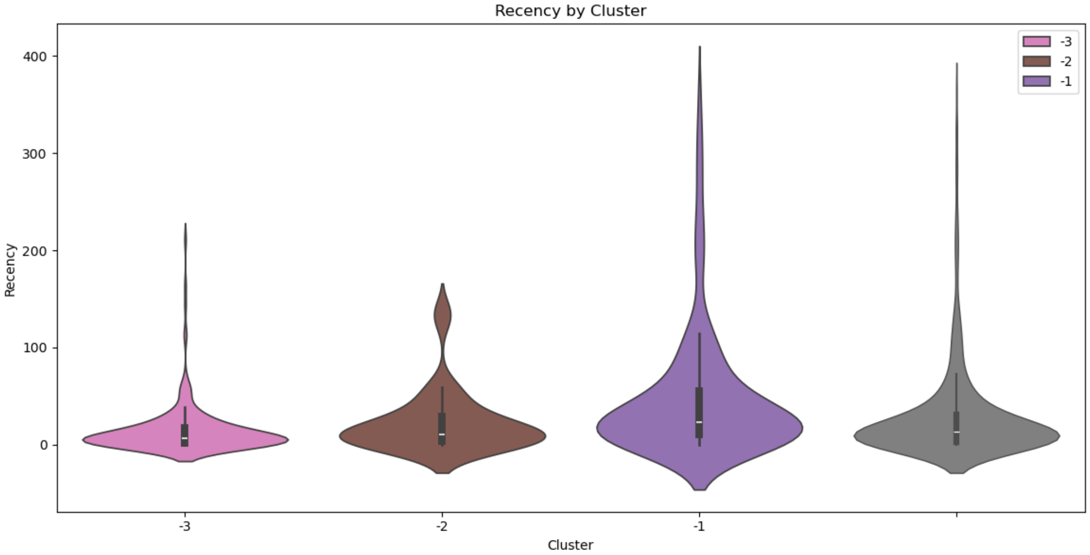
```
              Customer ID        MonetaryValue  Frequency     LastInvoiceDate  \
9                12357.00             11229.99          1 2010-11-16 10:05:00
25               12380.00              4782.84          4 2010-08-31 14:54:00
42               12409.00             12346.62          4 2010-10-15 10:24:00
48               12415.00             19468.84          4 2010-11-29 15:07:00
61               12431.00              4145.52         11 2010-12-01 10:03:00
…                      …                    …  …                        …
4235             18223.00              7516.31         12 2010-11-17 12:20:00
4236             18225.00              7545.14         15 2010-12-09 15:46:00
4237             18226.00              6650.83         15 2010-11-26 15:51:00
4241             18231.00              4791.80         23 2010-10-29 14:17:00
4262             18260.00              7318.91         17 2010-11-30 12:25:00

      Recency  Cluster
9          23       -1
25        100       -1
42         55       -1
48         10       -1
61          8       -1
…       …       …
4235       22       -3
4236        0       -3
4237       13       -3
4241       41       -3
4262        9       -3

[476 rows x 6 columns]
```

[59]:

```
cluster_colors = {-1: '#9467bd',
                  -2: '#8c564b',
                  -3: '#e377c2'}

plt.figure(figsize=(12, 18))

plt.subplot(3, 1, 1)
sns.violinplot(x=outlier_clusters_df['Cluster'],␣
 ↪y=outlier_clusters_df['MonetaryValue'], palette=cluster_colors,␣
 ↪hue=outlier_clusters_df["Cluster"])
sns.violinplot(y=outlier_clusters_df['MonetaryValue'], color='gray',␣
 ↪linewidth=1.0)
plt.title('Monetary Value by Cluster')
plt.ylabel('Monetary Value')

plt.subplot(3, 1, 2)
sns.violinplot(x=outlier_clusters_df['Cluster'],␣
 ↪y=outlier_clusters_df['Frequency'], palette=cluster_colors,␣
 ↪hue=outlier_clusters_df["Cluster"])
sns.violinplot(y=outlier_clusters_df['Frequency'], color='gray', linewidth=1.0)
plt.title('Frequency by Cluster')
plt.ylabel('Frequency')

plt.subplot(3, 1, 3)
sns.violinplot(x=outlier_clusters_df['Cluster'],␣
 ↪y=outlier_clusters_df['Recency'], palette=cluster_colors,␣
 ↪hue=outlier_clusters_df["Cluster"])
sns.violinplot(y=outlier_clusters_df['Recency'], color='gray', linewidth=1.0)
plt.title('Recency by Cluster')
plt.ylabel('Recency')

plt.tight_layout()
plt.show()
```


Monetary Value by Cluster
Monetary Value
350000
300000
250000
200000
150000
100000
50000
0
-3
-2
-1
Cluster
-3
-2
-1


Frequency by Cluster
Frequency
200
150
100
50
0
-3
-2
-1
Cluster
-3
-2
-1


Recency by Cluster
Recency
400
300
200
100
0
-3
-2
-1
Cluster
-3
-2
-1

[61]:

```
cluster_labels = {
    0: "RETAIN",
    1: "RE-ENGAGE",
    2: "NURTURE",
    3: "REWARD",
    -1: "PAMPER",
    -2: "UPSELL",
    -3: "DELIGHT"
}
```

[62]:

```
full_clustering_df = pd.concat([non_outliers_df, outlier_clusters_df])
full_clustering_df
```

[62]:

```
              Customer ID        MonetaryValue  Frequency     LastInvoiceDate  \
0                12346.00               169.36          2 2010-06-28 13:53:00
1                12347.00              1323.32          2 2010-12-07 14:57:00
2                12348.00               221.16          1 2010-09-27 14:59:00
3                12349.00              2221.14          2 2010-10-28 08:23:00
4                12351.00               300.93          1 2010-11-29 15:23:00
…                   …                  …        …                 …
4235             18223.00              7516.31         12 2010-11-17 12:20:00
4236             18225.00              7545.14         15 2010-12-09 15:46:00
4237             18226.00              6650.83         15 2010-11-26 15:51:00
4241             18231.00              4791.80         23 2010-10-29 14:17:00
4262             18260.00              7318.91         17 2010-11-30 12:25:00

      Recency  Cluster
0         164        1
1           2        0
2          73        2
3          42        0
4          10        2
…       …      …
4235       22       -3
4236        0       -3
4237       13       -3
4241       41       -3
4262        9       -3

[4285 rows x 6 columns]
```

[63]:

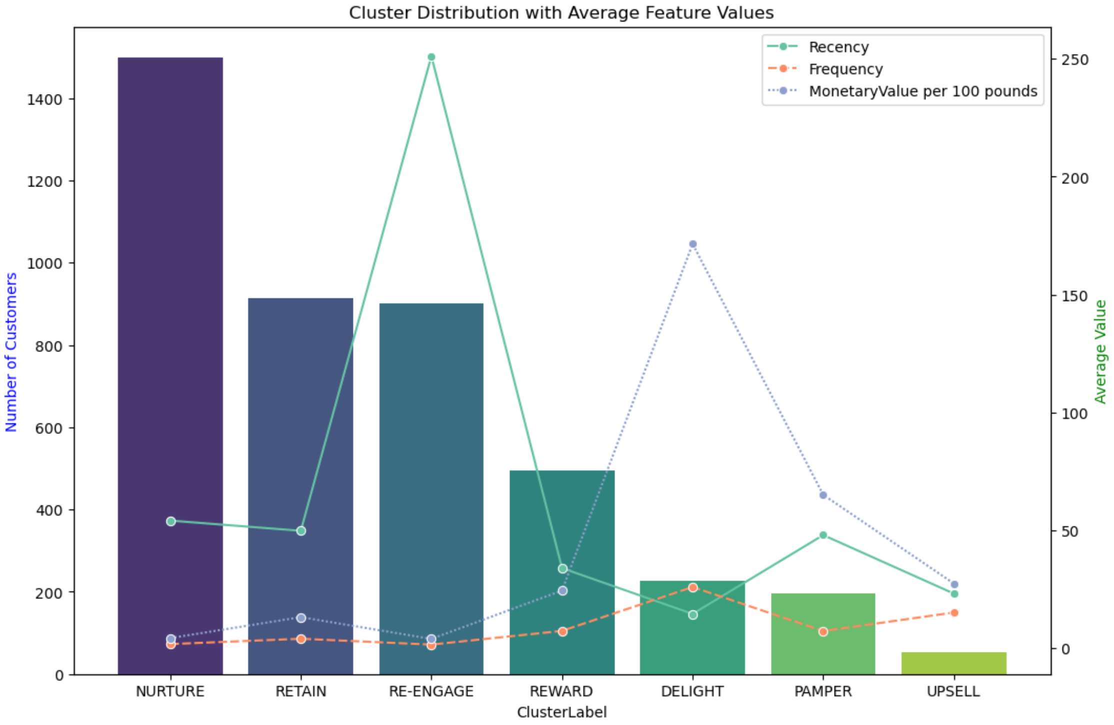
```
full_clustering_df["ClusterLabel"] = full_clustering_df["Cluster"].
  ↪map(cluster_labels)
full_clustering_df
```

```
[63]:          Customer ID      MonetaryValue  Frequency      LastInvoiceDate  \
      0            12346.00             169.36          2 2010-06-28 13:53:00
      1            12347.00            1323.32          2 2010-12-07 14:57:00
      2            12348.00             221.16          1 2010-09-27 14:59:00
      3            12349.00            2221.14          2 2010-10-28 08:23:00
      4            12351.00             300.93          1 2010-11-29 15:23:00
      …                   …                  …  …                    …
      4235         18223.00            7516.31         12 2010-11-17 12:20:00
      4236         18225.00            7545.14         15 2010-12-09 15:46:00
      4237         18226.00            6650.83         15 2010-11-26 15:51:00
      4241         18231.00            4791.80         23 2010-10-29 14:17:00
      4262         18260.00            7318.91         17 2010-11-30 12:25:00

            Recency  Cluster ClusterLabel
      0         164        1   RE-ENGAGE
      1           2        0      RETAIN
      2          73        2     NURTURE
      3          42        0      RETAIN
      4          10        2     NURTURE
      …       …      …          …
      4235       22       -3     DELIGHT
      4236        0       -3     DELIGHT
      4237       13       -3     DELIGHT
      4241       41       -3     DELIGHT
      4262        9       -3     DELIGHT

      [4285 rows x 7 columns]
```

6 VISUALISATION

```
[64]: cluster_counts = full_clustering_df['ClusterLabel'].value_counts()
      full_clustering_df["MonetaryValue per 100 pounds"] =␣
        ↪full_clustering_df["MonetaryValue"] / 100.00
      feature_means = full_clustering_df.groupby('ClusterLabel')[['Recency',␣
        ↪'Frequency', 'MonetaryValue per 100 pounds']].mean()

      fig, ax1 = plt.subplots(figsize=(12, 8))

      sns.barplot(x=cluster_counts.index, y=cluster_counts.values, ax=ax1,␣
        ↪palette='viridis', hue=cluster_counts.index)
      ax1.set_ylabel('Number of Customers', color='b')
      ax1.set_title('Cluster Distribution with Average Feature Values')

      ax2 = ax1.twinx()

      sns.lineplot(data=feature_means, ax=ax2, palette='Set2', marker='o')
```

```
ax2.set_ylabel('Average Value', color='g')

plt.show()
```



```
[ ]:
```