In [4]:

```
import os
import warnings
warnings.simplefilter(action = 'ignore', category=FutureWarning)
warnings.filterwarnings('ignore')
def ignore_warn(*args, **kwargs):
    pass

warnings.warn = ignore_warn #ignore annoying warning (from sklearn and seaborn)

import pandas as pd
import datetime
import math
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.mlab as mlab
import matplotlib.cm as cm

%matplotlib inline

from pandasql import sqldf
pysqldf = lambda q: sqldf(q, globals())

import seaborn as sns
sns.set(style="ticks", color_codes=True, font_scale=1.5)
color = sns.color_palette()
sns.set_style('darkgrid')

from mpl_toolkits.mplot3d import Axes3D

import plotly as py
import plotly.graph_objs as go
py.offline.init_notebook_mode()

from scipy import stats
from scipy.stats import skew, norm, probplot, boxcox
from sklearn import preprocessing
import math

from sklearn.cluster import KMeans
from sklearn.metrics import silhouette_samples, silhouette_score

import Orange
from Orange.data import Domain, DiscreteVariable, ContinuousVariable
from orangecontrib.associate.fpgrowth import *
```

In [11]:

```
cs_df = pd.read_excel("C:/Users/aditya/Downloads/archive (4)/Online Retail.xlsx")
```

In [12]:

```
def rstr(df, pred=None):
    obs = df.shape[0]
    types = df.dtypes
    counts = df.apply(lambda x: x.count())
    distincts = df.apply(lambda x: x.nunique())  # count of distinct values
    nulls = df.isnull().sum()
    missing_ration = (nulls / obs) * 100
    skewness = df.skew(numeric_only=True)
    kurtosis = df.kurt(numeric_only=True)

    # store unique values safely as a single object column
    uniques = df.apply(lambda x: x.unique()[:10])  # keep only first 10 unique valu

    print('Data shape:', df.shape)

    if pred is None:
        str_ = pd.concat(
            [types, counts, distincts, nulls, missing_ration, uniques, skewness, ku
            axis=1
        )
        cols = ['types', 'counts', 'distincts', 'nulls', 'missing ration', 'uniques
    else:
        corr = df.corr(numeric_only=True)[pred]
        str_ = pd.concat(
            [types, counts, distincts, nulls, missing_ration, uniques, skewness, ku
            axis=1
        )
        corr_col = 'corr ' + pred
        cols = ['types', 'counts', 'distincts', 'nulls', 'missing ration', 'uniques

    str_.columns = cols
    print('___________________________\nData types:\n', str_['types'].value_counts(
    print('___________________________')

    return str_
```

In [13]:

```
cs_df.describe()
```

Out[13]:

	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 [14]:

```
print('Check if we had negative quantity and prices at same register:',
     'No' if cs_df[(cs_df.Quantity<0) & (cs_df.UnitPrice<0)].shape[0] == 0 else 'Ye
print('Check how many register we have where quantity is negative',
      'and prices is 0 or vice-versa:',
      cs_df[(cs_df.Quantity<=0) & (cs_df.UnitPrice<=0)].shape[0])
print('\nWhat is the customer ID of the registers above:',
      cs_df.loc[(cs_df.Quantity<=0) & (cs_df.UnitPrice<=0),
                ['CustomerID']].CustomerID.unique())
print('\n% Negative Quantity: {:3.2%}'.format(cs_df[(cs_df.Quantity<0)].shape[0]/cs
print('\nAll register with negative quantity has Invoice start with:',
      cs_df.loc[(cs_df.Quantity<0) & ~(cs_df.CustomerID.isnull()), 'InvoiceNo'].app
print('\nSee an example of negative quantity and others related records:')
display(cs_df[(cs_df.CustomerID==12472) & (cs_df.StockCode==22244)])
```

```
Check if we had negative quantity and prices at same register: No

Check how many register we have where quantity is negative and prices is 0 or vice-
versa: 1336

What is the customer ID of the registers above: [nan]

% Negative Quantity: 1.96%

All register with negative quantity has Invoice start with: ['C']

See an example of negative quantity and others related records:
```

	InvoiceNo	StockCode	Description	Quantity	InvoiceDate	UnitPrice	CustomerID	Countr
1973	C536548	22244	3 HOOK HANGER MAGIC GARDEN	-4	2010-12-01 14:33:00	1.95	12472.0	Germar
9438	537201	22244	3 HOOK HANGER MAGIC GARDEN	12	2010-12-05 14:19:00	1.95	12472.0	Germar
121980	546843	22244	3 HOOK HANGER MAGIC GARDEN	12	2011-03-17 12:40:00	1.95	12472.0	Germar

In [15]:

```
print('Check register with UnitPrice negative:')
display(cs_df[(cs_df.UnitPrice<0)])
print("Sales records with Customer ID and zero in Unit Price:",cs_df[(cs_df.UnitPri
cs_df[(cs_df.UnitPrice==0)  & ~(cs_df.CustomerID.isnull())]
```

```
Check register with UnitPrice negative:
```

	InvoiceNo	StockCode	Description	Quantity	InvoiceDate	UnitPrice	CustomerID	Countr
299983	A563186	B	Adjust bad debt	1	2011-08-12 14:51:00	-11062.06	NaN	Unite Kingdo
299984	A563187	B	Adjust bad debt	1	2011-08-12 14:52:00	-11062.06	NaN	Unite Kingdo

```
Sales records with Customer ID and zero in Unit Price: 40
```

Out[15]:

	InvoiceNo	StockCode	Description	Quantity	InvoiceDate	UnitPrice	CustomerID	C
9302	537197	22841	ROUND CAKE TIN VINTAGE GREEN	1	2010-12-05 14:02:00	0.0	12647.0	Ge
33576	539263	22580	ADVENT CALENDAR GINGHAM SACK	4	2010-12-16 14:36:00	0.0	16560.0	Ki
40089	539722	22423	REGENCY CAKESTAND 3 TIER	10	2010-12-21 13:45:00	0.0	14911.0	
47068	540372	22090	PAPER BUNTING RETROSPOT	24	2011-01-06 16:41:00	0.0	13081.0	Ki
47070	540372	22553	PLASTERS IN TIN SKULLS	24	2011-01-06 16:41:00	0.0	13081.0	Ki
56674	541109	22168	ORGANISER WOOD ANTIQUE WHITE	1	2011-01-13 15:10:00	0.0	15107.0	Ki
86789	543599	84535B	FAIRY CAKES NOTEBOOK A6 SIZE	16	2011-02-10 13:08:00	0.0	17560.0	Ki
130188	547417	22062	CERAMIC BOWL WITH LOVE HEART DESIGN	36	2011-03-23 10:25:00	0.0	13239.0	Ki
139453	548318	22055	MINI CAKE STAND HANGING STRAWBERY	5	2011-03-30 12:45:00	0.0	13113.0	Ki
145208	548871	22162	HEART GARLAND RUSTIC PADDED	2	2011-04-04 14:42:00	0.0	14410.0	Ki
157042	550188	22636	CHILDS BREAKFAST SET CIRCUS PARADE	1	2011-04-14 18:57:00	0.0	12457.0	Swit
187613	553000	47566	PARTY BUNTING	4	2011-05-12 15:21:00	0.0	17667.0	Ki
198383	554037	22619	SET OF 6 SOLDIER SKITTLES	80	2011-05-20 14:13:00	0.0	12415.0	A
279324	561284	22167	OVAL WALL MIRROR DIAMANTE	1	2011-07-26 12:24:00	0.0	16818.0	Ki

	InvoiceNo	StockCode	Description	Quantity	InvoiceDate	UnitPrice	CustomerID	C
282912	561669	22960	JAM MAKING SET WITH JARS	11	2011-07-28 17:09:00	0.0	12507.0	
285657	561916	M	Manual	1	2011-08-01 11:44:00	0.0	15581.0	Ki
298054	562973	23157	SET OF 6 NATIVITY MAGNETS	240	2011-08-11 11:42:00	0.0	14911.0	
314745	564651	23270	SET OF 2 CERAMIC PAINTED HEARTS	96	2011-08-26 14:19:00	0.0	14646.0	Neth
314746	564651	23268	SET OF 2 CERAMIC CHRISTMAS REINDEER	192	2011-08-26 14:19:00	0.0	14646.0	Neth
314747	564651	22955	36 FOIL STAR CAKE CASES	144	2011-08-26 14:19:00	0.0	14646.0	Neth
314748	564651	21786	POLKADOT RAIN HAT	144	2011-08-26 14:19:00	0.0	14646.0	Neth
358655	568158	PADS	PADS TO MATCH ALL CUSHIONS	1	2011-09-25 12:22:00	0.0	16133.0	Ki
361825	568384	M	Manual	1	2011-09-27 09:46:00	0.0	12748.0	Ki
379913	569716	22778	GLASS CLOCHE SMALL	2	2011-10-06 08:17:00	0.0	15804.0	Ki
395529	571035	M	Manual	1	2011-10-13 12:50:00	0.0	12446.0	
420404	572893	21208	PASTEL COLOUR HONEYCOMB FAN	5	2011-10-26 14:36:00	0.0	18059.0	Ki
436428	574138	23234	BISCUIT TIN VINTAGE CHRISTMAS	216	2011-11-03 11:26:00	0.0	12415.0	A
436597	574175	22065	CHRISTMAS PUDDING TRINKET POT	12	2011-11-03 11:47:00	0.0	14110.0	Ki
436961	574252	M	Manual	1	2011-11-03 13:24:00	0.0	12437.0	
439361	574469	22385	JUMBO BAG SPACEBOY DESIGN	12	2011-11-04 11:55:00	0.0	12431.0	A

	InvoiceNo	StockCode	Description	Quantity	InvoiceDate	UnitPrice	CustomerID	C
446125	574879	22625	RED KITCHEN SCALES	2	2011-11-07 13:22:00	0.0	13014.0	Ki
446793	574920	22899	CHILDREN'S APRON DOLLY GIRL	1	2011-11-07 16:34:00	0.0	13985.0	Ki
446794	574920	23480	MINI LIGHTS WOODLAND MUSHROOMS	1	2011-11-07 16:34:00	0.0	13985.0	Ki
454463	575579	22437	SET OF 9 BLACK SKULL BALLOONS	20	2011-11-10 11:49:00	0.0	13081.0	Ki
454464	575579	22089	PAPER BUNTING VINTAGE PAISLEY	24	2011-11-10 11:49:00	0.0	13081.0	Ki
479079	577129	22464	HANGING METAL HEART LANTERN	4	2011-11-17 19:52:00	0.0	15602.0	Ki
479546	577168	M	Manual	1	2011-11-18 10:42:00	0.0	12603.0	Ge
480649	577314	23407	SET OF 2 TRAYS HOME SWEET HOME	2	2011-11-18 13:23:00	0.0	12444.0	N
485985	577696	M	Manual	1	2011-11-21 11:57:00	0.0	16406.0	Ki
502122	578841	84826	ASSTD DESIGN 3D PAPER STICKERS	12540	2011-11-25 15:57:00	0.0	13256.0	Ki

In [21]:

```
import pandas as pd

def rstr(df, pred=None):
    obs = df.shape[0]
    types = df.dtypes
    counts = df.count()
    distincts = df.nunique()
    nulls = df.isnull().sum()
    missing_ration = (nulls / obs) * 100
    skewness = df.skew(numeric_only=True)
    kurtosis = df.kurt(numeric_only=True)

    # Show only a few unique values, force into one column
    uniques = df.apply(lambda x: list(x.dropna().unique()[:5]))  # first 5 uniques
    uniques = uniques.astype(str)  # make sure it stays one column

    print('Data shape:', df.shape)

    if pred is None:
        str_ = pd.concat(
            [types, counts, distincts, nulls, missing_ration, uniques, skewness, ku
            axis=1
        )
        cols = ['types', 'counts', 'distincts', 'nulls', 'missing ration',
                'uniques', 'skewness', 'kurtosis']
    else:
        corr = df.corr(numeric_only=True)[pred]
        str_ = pd.concat(
            [types, counts, distincts, nulls, missing_ration, uniques, skewness, ku
            axis=1
        )
        corr_col = 'corr ' + pred
        cols = ['types', 'counts', 'distincts', 'nulls', 'missing ration',
                'uniques', 'skewness', 'kurtosis', corr_col]

    # align length safely (truncate or expand)
    str_ = str_.iloc[:, :len(cols)]
    str_.columns = cols

    print('___________________________\nData types:\n', str_['types'].value_counts(
    print('___________________________')

    return str_
```

In [22]:

```
cs_df = cs_df[~(cs_df.CustomerID.isnull())]
cs_df = cs_df[~(cs_df.Quantity < 0)]
cs_df = cs_df[cs_df.UnitPrice > 0]

details = rstr(cs_df)
display(details.sort_values(by='distincts', ascending=False))
```

```
Data shape: (397884, 8)
___________________________
Data types:
 object          4
float64          2
int64            1
datetime64[ns]   1
Name: types, dtype: int64
___________________________
```

	types	counts	distincts	nulls	missing ration	uniques	skewness	kurtosis
InvoiceNo	object	397884.0	18532.0	0.0	0.0	NaN	NaN	NaN
InvoiceDate	datetime64[ns]	397884.0	17282.0	0.0	0.0	NaN	NaN	NaN
CustomerID	float64	397884.0	4338.0	0.0	0.0	NaN	NaN	NaN
Description	object	397884.0	3877.0	0.0	0.0	NaN	NaN	NaN
StockCode	object	397884.0	3665.0	0.0	0.0	NaN	NaN	NaN
UnitPrice	float64	397884.0	440.0	0.0	0.0	NaN	NaN	NaN
Quantity	int64	397884.0	301.0	0.0	0.0	NaN	NaN	NaN
Country	object	397884.0	37.0	0.0	0.0	NaN	NaN	NaN
0	NaN	NaN	NaN	NaN	NaN	536365	85123A	WHITE HANGING HEART T-LIGHT HOLDER
1	NaN	NaN	NaN	NaN	NaN	536366	71053	WHITE METAL LANTERN
2	NaN	NaN	NaN	NaN	NaN	536367	84406B	CREAM CUPID HEARTS COAT HANGER
3	NaN	NaN	NaN	NaN	NaN	536368	84029G	KNITTED UNION FLAG HOT WATER BOTTLE
4	NaN	NaN	NaN	NaN	NaN	536369	84029E	RED WOOLLY HOTTIE WHITE HEART.

In [23]:
```
cat_des_df = cs_df.groupby(["StockCode","Description"]).count().reset_index()
display(cat_des_df.StockCode.value_counts()[cat_des_df.StockCode.value_counts()>1].
cs_df[cs_df['StockCode'] == cat_des_df.StockCode.value_counts()[cat_des_df.StockCod
      .reset_index()['index'][4]]['Description'].unique()
```

	index	StockCode
0	23196	4
1	23236	4
2	23203	3
3	17107D	3
4	23535	3

Out[23]:

```
array(['BICYCLE SAFTEY WALL ART', 'WALL ART BICYCLE SAFTEY ',
       'WALL ART BICYCLE SAFETY'], dtype=object)
```

In [24]:

```
unique_desc = cs_df[["StockCode", "Description"]].groupby(by=["StockCode"]).\
                apply(pd.DataFrame.mode).reset_index(drop=True)
q = '''
select df.InvoiceNo, df.StockCode, un.Description, df.Quantity, df.InvoiceDate,
       df.UnitPrice, df.CustomerID, df.Country
from cs_df as df INNER JOIN
     unique_desc as un on df.StockCode = un.StockCode
'''

cs_df = pysqldf(q)
```

In [25]:

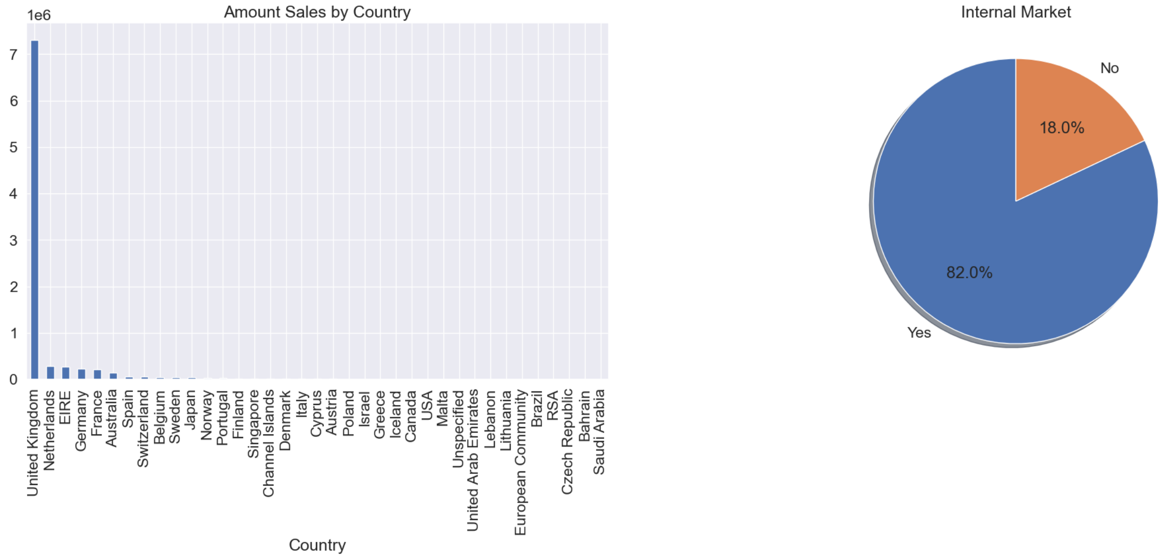
```
cs_df.InvoiceDate = pd.to_datetime(cs_df.InvoiceDate)
cs_df['amount'] = cs_df.Quantity*cs_df.UnitPrice
cs_df.CustomerID = cs_df.CustomerID.astype('Int64')

details = rstr(cs_df)
display(details.sort_values(by='distincts', ascending=False))
```

```
Data shape: (397884, 9)
___________________________
Data types:
 object            3
int64             2
float64           2
datetime64[ns]    1
Int64             1
Name: types, dtype: int64
___________________________
```

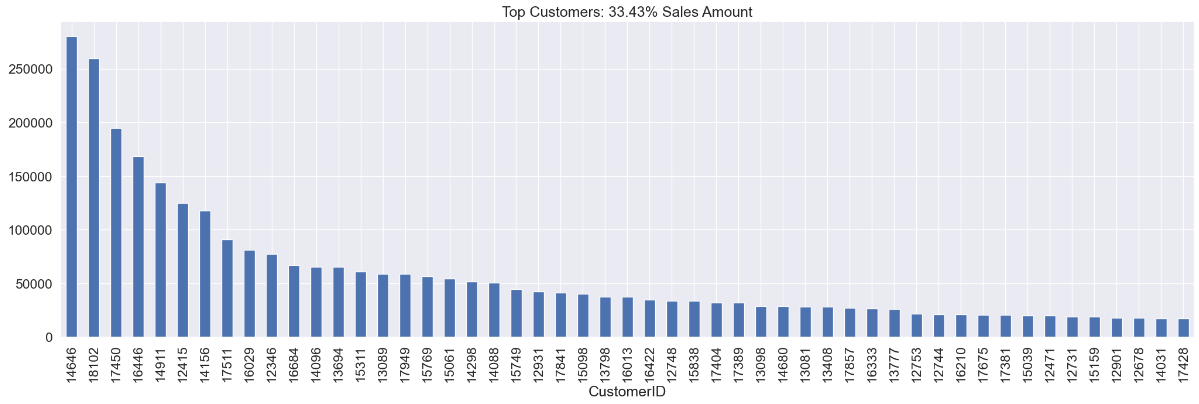
	types	counts	distincts	nulls	missing ration	uniques	skewness	kurtosis
InvoiceNo	int64	397884.0	18532.0	0.0	0.0	NaN	NaN	NaN
InvoiceDate	datetime64[ns]	397884.0	17282.0	0.0	0.0	NaN	NaN	NaN
CustomerID	Int64	397884.0	4338.0	0.0	0.0	NaN	NaN	NaN
StockCode	object	397884.0	3665.0	0.0	0.0	NaN	NaN	NaN
Description	object	397884.0	3647.0	0.0	0.0	NaN	NaN	NaN
amount	float64	397884.0	2939.0	0.0	0.0	NaN	NaN	NaN
UnitPrice	float64	397884.0	440.0	0.0	0.0	NaN	NaN	NaN
Quantity	int64	397884.0	301.0	0.0	0.0	NaN	NaN	NaN
Country	object	397884.0	37.0	0.0	0.0	NaN	NaN	NaN
0	NaN	NaN	NaN	NaN	NaN	536365	85123A	WHITE HANGING HEART T-LIGHT HOLDER
1	NaN	NaN	NaN	NaN	NaN	536366	71053	WHITE METAL LANTERN
2	NaN	NaN	NaN	NaN	NaN	536367	84406B	CREAM CUPID HEARTS COAT HANGER
3	NaN	NaN	NaN	NaN	NaN	536368	84029G	KNITTED UNION FLAG HOT WATER BOTTLE
4	NaN	NaN	NaN	NaN	NaN	536369	84029E	RED WOOLLY HOTTIE WHITE HEART.

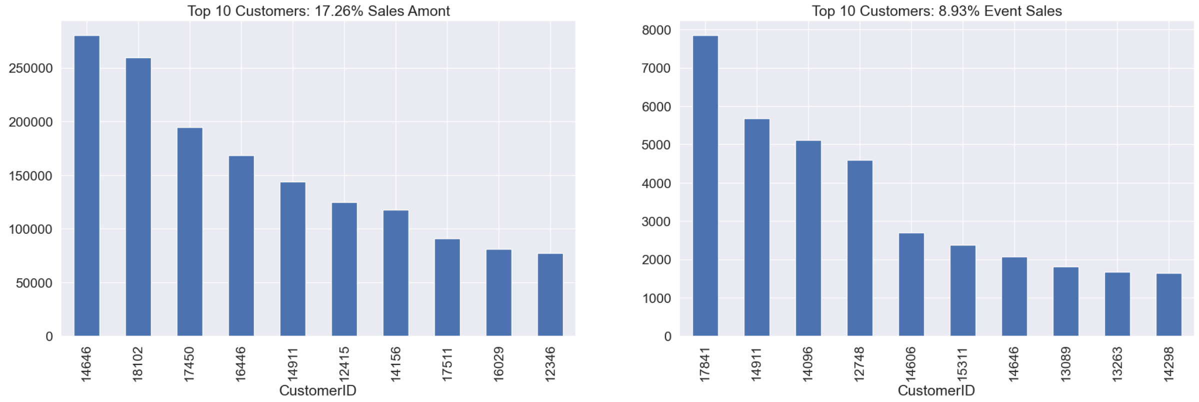
In [26]:

```
fig = plt.figure(figsize=(25, 7))
f1 = fig.add_subplot(121)
g = cs_df.groupby(["Country"]).amount.sum().sort_values(ascending = False).plot(kin
cs_df['Internal'] = cs_df.Country.apply(lambda x: 'Yes' if x=='United Kingdom' else
f2 = fig.add_subplot(122)
market = cs_df.groupby(["Internal"]).amount.sum().sort_values(ascending = False)
g = plt.pie(market, labels=market.index, autopct='%1.1f%%', shadow=True, startangle
plt.title('Internal Market')
plt.show()
```



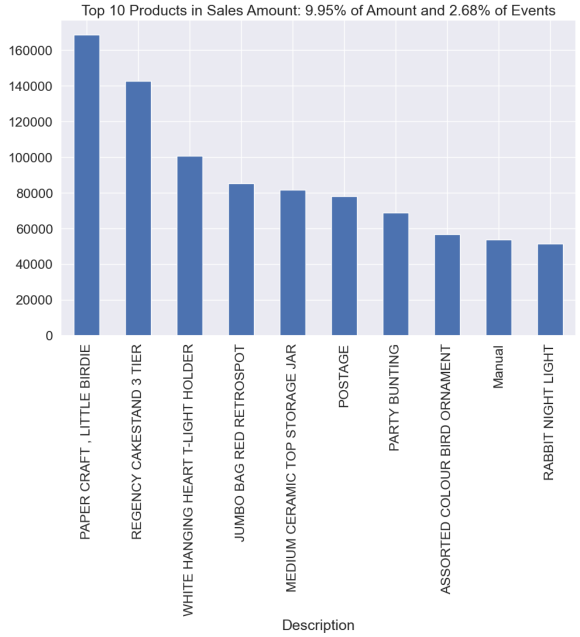
In [27]:
```
fig = plt.figure(figsize=(25, 7))
PercentSales =  np.round((cs_df.groupby(["CustomerID"]).amount.sum().\
                          sort_values(ascending = False)[:51].sum()/cs_df.groupby([
                          amount.sum().sort_values(ascending = False).sum()) * 100,
g = cs_df.groupby(["CustomerID"]).amount.sum().sort_values(ascending = False)[:51].
    plot(kind='bar', title='Top Customers: {:3.2f}% Sales Amount'.format(PercentSal

fig = plt.figure(figsize=(25, 7))
f1 = fig.add_subplot(121)
PercentSales =  np.round((cs_df.groupby(["CustomerID"]).amount.sum().\
                          sort_values(ascending = False)[:10].sum()/cs_df.groupby([
                          amount.sum().sort_values(ascending = False).sum()) * 100,
g = cs_df.groupby(["CustomerID"]).amount.sum().sort_values(ascending = False)[:10]\
    .plot(kind='bar', title='Top 10 Customers: {:3.2f}% Sales Amont'.format(Percent
f1 = fig.add_subplot(122)
PercentSales =  np.round((cs_df.groupby(["CustomerID"]).amount.count().\
                          sort_values(ascending = False)[:10].sum()/cs_df.groupby([
                          amount.count().sort_values(ascending = False).sum()) * 10
g = cs_df.groupby(["CustomerID"]).amount.count().sort_values(ascending = False)[:10
    plot(kind='bar', title='Top 10 Customers: {:3.2f}% Event Sales'.format(PercentS
```

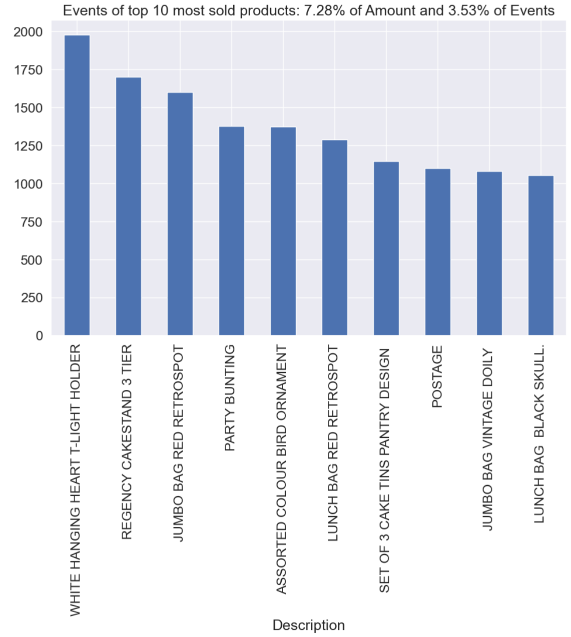


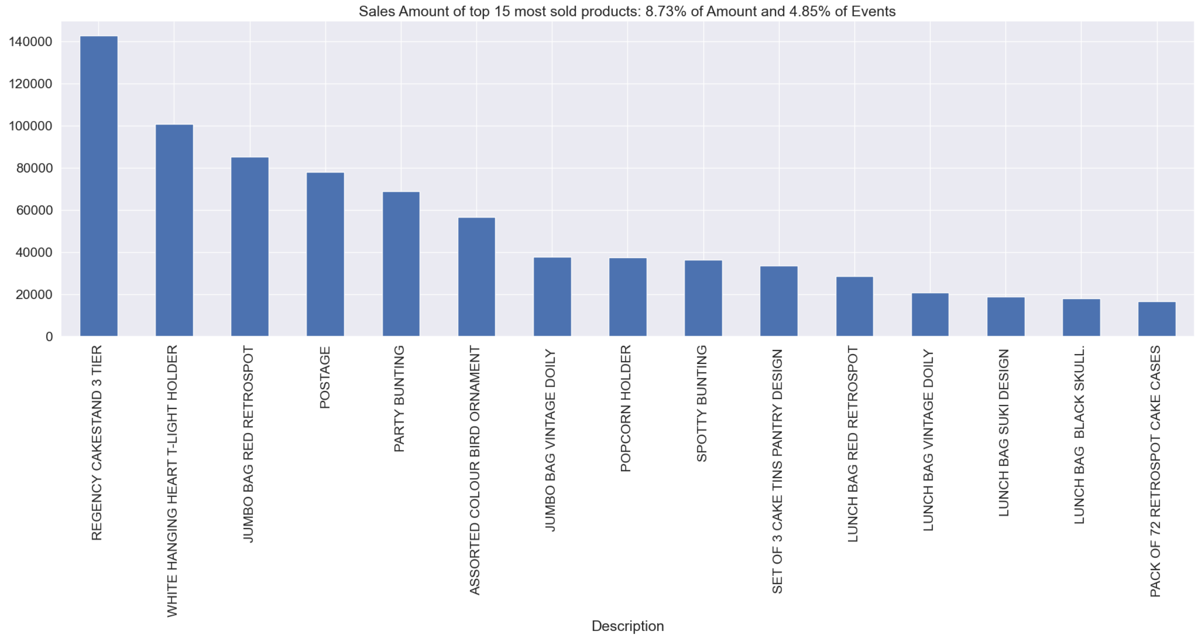

Top 10 Customers: 17.26% Sales Amont
0
50000
100000
150000
200000
250000
14646
18102
17450
16446
14911
12415
14156
17511
16029
12346
CustomerID
Top 10 Customers: 8.93% Event Sales
0
1000
2000
3000
4000
5000
6000
7000
8000
17841
14911
14096
12748
14606
15311
14646
13089
13263
14298
CustomerID

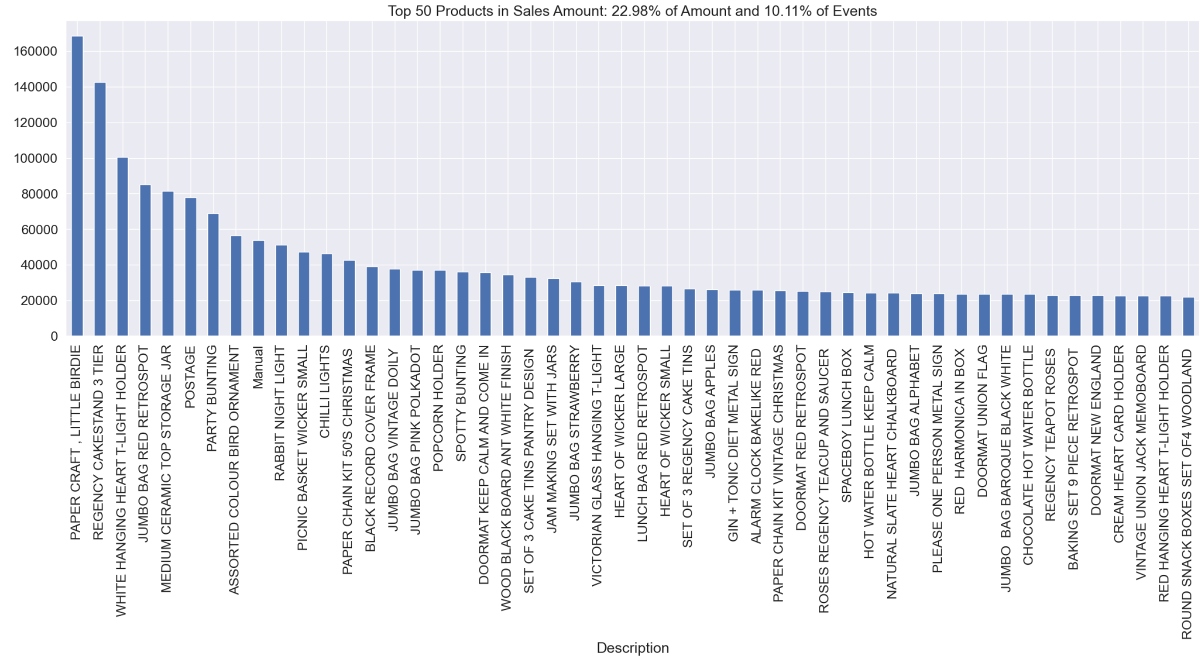
In [28]:

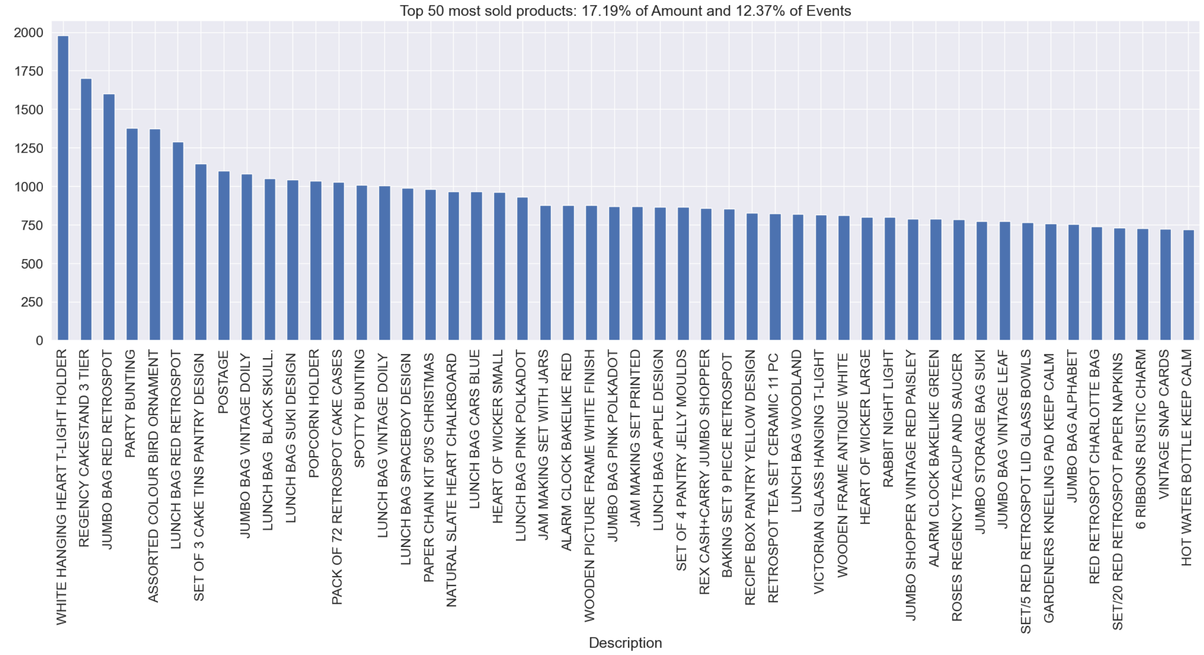
```
AmoutSum = cs_df.groupby(["Description"]).amount.sum().sort_values(ascending = Fals
inv = cs_df[["Description", "InvoiceNo"]].groupby(["Description"]).InvoiceNo.unique
      agg(np.size).sort_values(ascending = False)

fig = plt.figure(figsize=(25, 7))
f1 = fig.add_subplot(121)
Top10 = list(AmoutSum[:10].index)
PercentSales =  np.round((AmoutSum[Top10].sum()/AmoutSum.sum()) * 100, 2)
PercentEvents = np.round((inv[Top10].sum()/inv.sum()) * 100, 2)
g = AmoutSum[Top10].\
    plot(kind='bar', title='Top 10 Products in Sales Amount: {:3.2f}% of Amount and
                       format(PercentSales, PercentEvents))

f1 = fig.add_subplot(122)
Top10Ev = list(inv[:10].index)
PercentSales =  np.round((AmoutSum[Top10Ev].sum()/AmoutSum.sum()) * 100, 2)
PercentEvents = np.round((inv[Top10Ev].sum()/inv.sum()) * 100, 2)
g = inv[Top10Ev].\
    plot(kind='bar', title='Events of top 10 most sold products: {:3.2f}% of Amount
                       format(PercentSales, PercentEvents))


fig = plt.figure(figsize=(25, 7))
Top15ev = list(inv[:15].index)
PercentSales =  np.round((AmoutSum[Top15ev].sum()/AmoutSum.sum()) * 100, 2)
PercentEvents = np.round((inv[Top15ev].sum()/inv.sum()) * 100, 2)
g = AmoutSum[Top15ev].sort_values(ascending = False).\
    plot(kind='bar',
         title='Sales Amount of top 15 most sold products: {:3.2f}% of Amount and {
         format(PercentSales, PercentEvents))

fig = plt.figure(figsize=(25, 7))
Top50 = list(AmoutSum[:50].index)
PercentSales =  np.round((AmoutSum[Top50].sum()/AmoutSum.sum()) * 100, 2)
PercentEvents = np.round((inv[Top50].sum()/inv.sum()) * 100, 2)
g = AmoutSum[Top50].\
    plot(kind='bar',
         title='Top 50 Products in Sales Amount: {:3.2f}% of Amount and {:3.2f}% of
         format(PercentSales, PercentEvents))

fig = plt.figure(figsize=(25, 7))
Top50Ev = list(inv[:50].index)
PercentSales =  np.round((AmoutSum[Top50Ev].sum()/AmoutSum.sum()) * 100, 2)
PercentEvents = np.round((inv[Top50Ev].sum()/inv.sum()) * 100, 2)
g = inv[Top50Ev].\
    plot(kind='bar', title='Top 50 most sold products: {:3.2f}% of Amount and {:3.2
                       format(PercentSales, PercentEvents))
```


Top 10 Products in Sales Amount: 9.95% of Amount and 2.68% of Events


Events of top 10 most sold products: 7.28% of Amount and 3.53% of Events


Sales Amount of top 15 most sold products: 8.73% of Amount and 4.85% of Events





In [29]:

```
refrence_date = cs_df.InvoiceDate.max() + datetime.timedelta(days = 1)
print('Reference Date:', refrence_date)
cs_df['days_since_last_purchase'] = (refrence_date - cs_df.InvoiceDate).astype('tim
customer_history_df =  cs_df[['CustomerID', 'days_since_last_purchase']].groupby("C
customer_history_df.rename(columns={'days_since_last_purchase':'recency'}, inplace=
customer_history_df.describe().transpose()
```

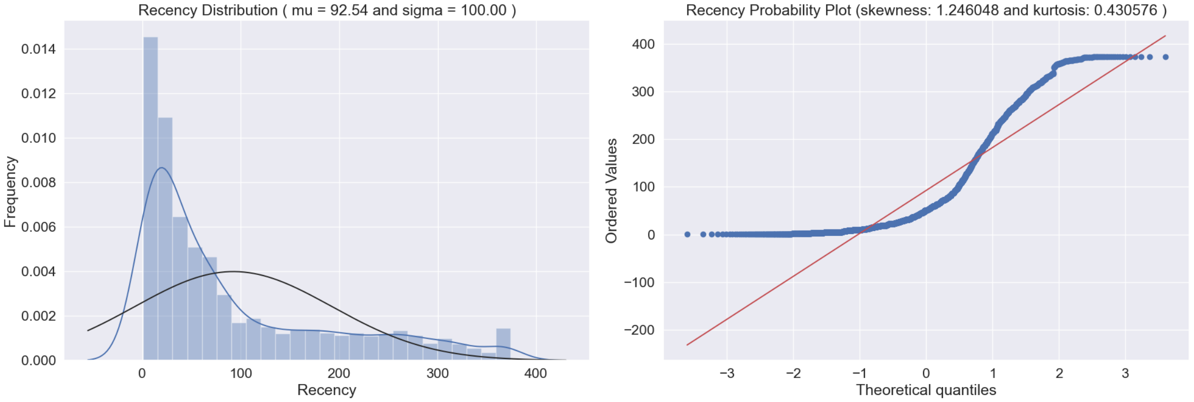
```
Reference Date: 2011-12-10 12:50:00
```

Out[29]:

	count	mean	std	min	25%	50%	75%	max
CustomerID	4338.0	15300.408022	1721.808492	12346.0	13813.25	15299.5	16778.75	18287.0
recency	4338.0	92.536422	100.014169	1.0	18.0	51.0	142.0	374.0

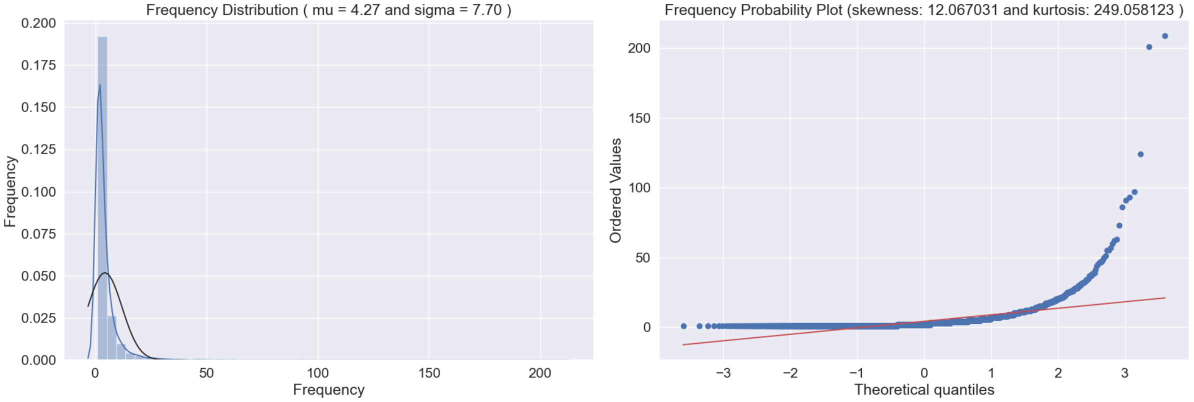
In [30]:

```
def QQ_plot(data, measure):
    fig = plt.figure(figsize=(20,7))

    #Get the fitted parameters used by the function
    (mu, sigma) = norm.fit(data)

    #Kernel Density plot
    fig1 = fig.add_subplot(121)
    sns.distplot(data, fit=norm)
    fig1.set_title(measure + ' Distribution ( mu = {:.2f} and sigma = {:.2f} )'.for
    fig1.set_xlabel(measure)
    fig1.set_ylabel('Frequency')

    #QQ plot
    fig2 = fig.add_subplot(122)
    res = probplot(data, plot=fig2)
    fig2.set_title(measure + ' Probability Plot (skewness: {:.6f} and kurtosis: {:.

    plt.tight_layout()
    plt.show()

QQ_plot(customer_history_df.recency, 'Recency')
```

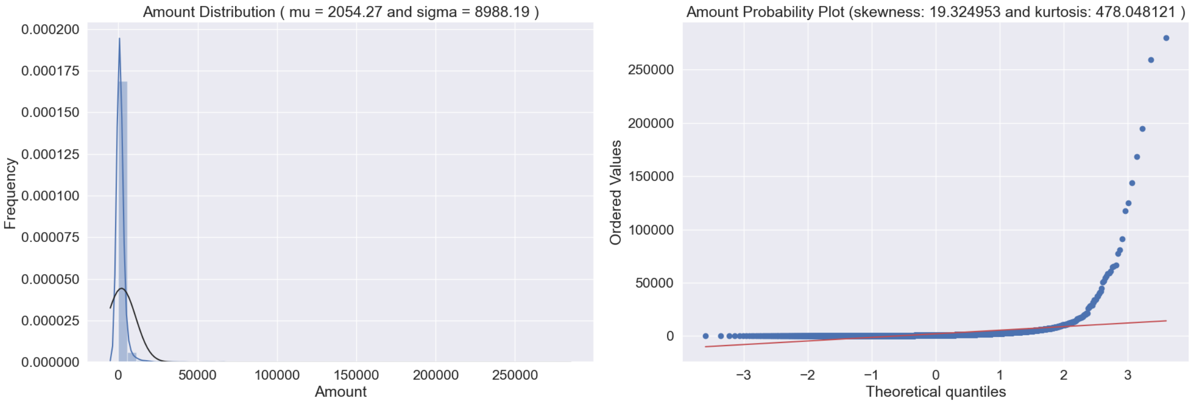


In [31]:

```
customer_freq = (cs_df[['CustomerID', 'InvoiceNo']].groupby(["CustomerID", 'Invoice
                 groupby(["CustomerID"]).count().reset_index()
customer_freq.rename(columns={'InvoiceNo':'frequency'},inplace=True)
customer_history_df = customer_history_df.merge(customer_freq)
QQ_plot(customer_history_df.frequency, 'Frequency')
```



In [32]:
```
customer_monetary_val = cs_df[['CustomerID', 'amount']].groupby("CustomerID").sum()
customer_history_df = customer_history_df.merge(customer_monetary_val)
QQ_plot(customer_history_df.amount, 'Amount')
```



In [33]:
```
customer_history_df.describe()
```

Out[33]:

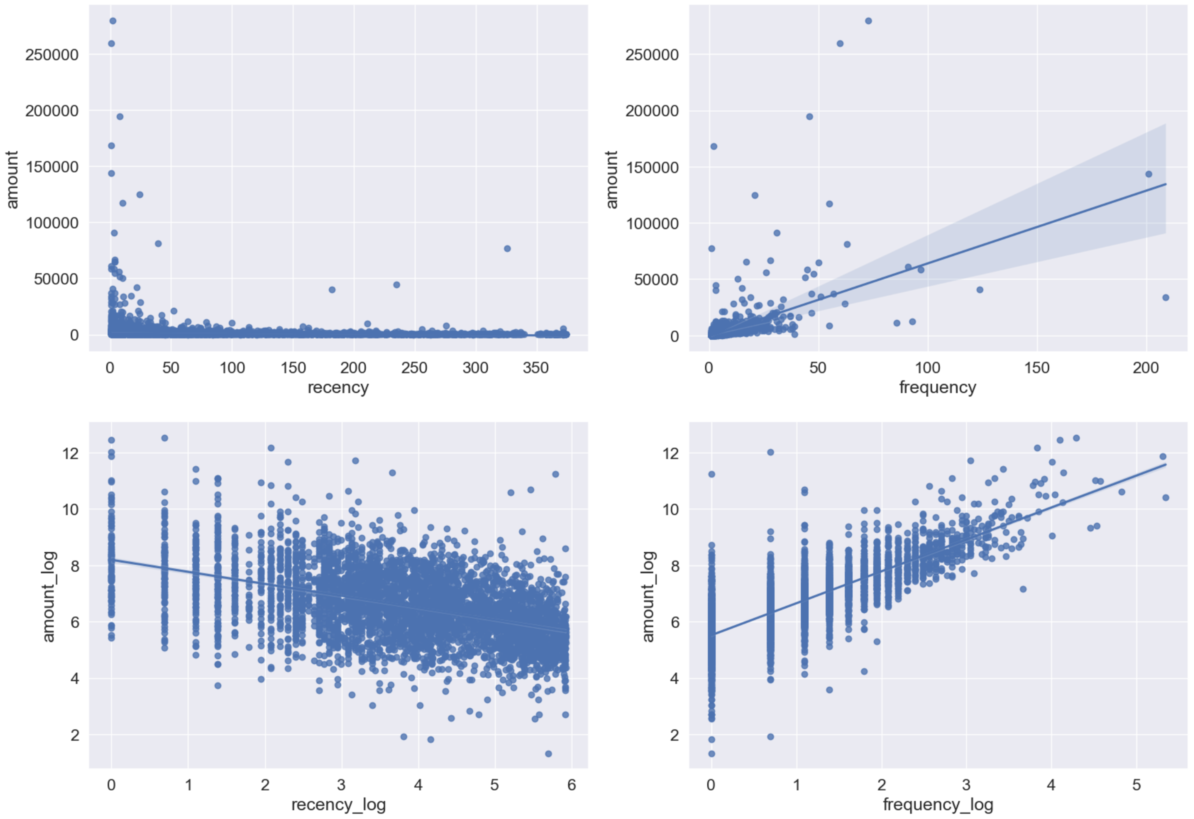
	CustomerID	recency	frequency	amount
count	4338.0	4338.000000	4338.000000	4338.000000
mean	15300.408022	92.536422	4.272015	2054.266460
std	1721.808492	100.014169	7.697998	8989.230441
min	12346.0	1.000000	1.000000	3.750000
25%	13813.25	18.000000	1.000000	307.415000
50%	15299.5	51.000000	2.000000	674.485000
75%	16778.75	142.000000	5.000000	1661.740000
max	18287.0	374.000000	209.000000	280206.020000

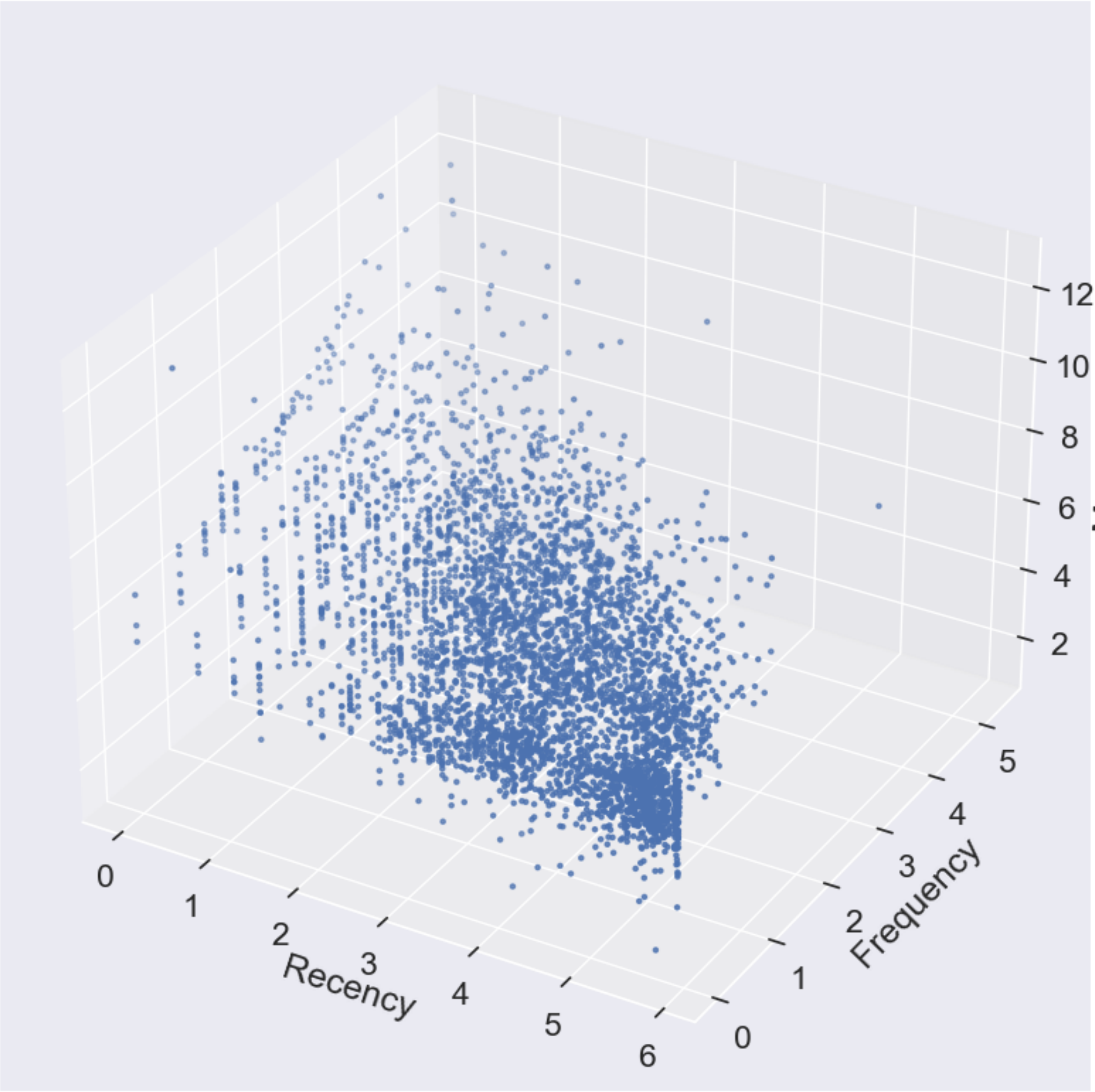
In [34]:
```
customer_history_df['recency_log'] = customer_history_df['recency'].apply(math.log)
customer_history_df['frequency_log'] = customer_history_df['frequency'].apply(math.
customer_history_df['amount_log'] = customer_history_df['amount'].apply(math.log)
feature_vector = ['amount_log', 'recency_log','frequency_log']
X_subset = customer_history_df[feature_vector] #.as_matrix()
scaler = preprocessing.StandardScaler().fit(X_subset)
X_scaled = scaler.transform(X_subset)
pd.DataFrame(X_scaled, columns=X_subset.columns).describe().T
```

Out[34]:

	count	mean	std	min	25%	50%	75%	max
amount_log	4338.0	-7.010426e-16	1.000115	-4.179280	-0.684183	-0.060942	0.654244	4.721395
recency_log	4338.0	-1.048288e-16	1.000115	-2.630445	-0.612424	0.114707	0.829652	1.505796
frequency_log	4338.0	-9.991495e-17	1.000115	-1.048610	-1.048610	-0.279044	0.738267	4.882714

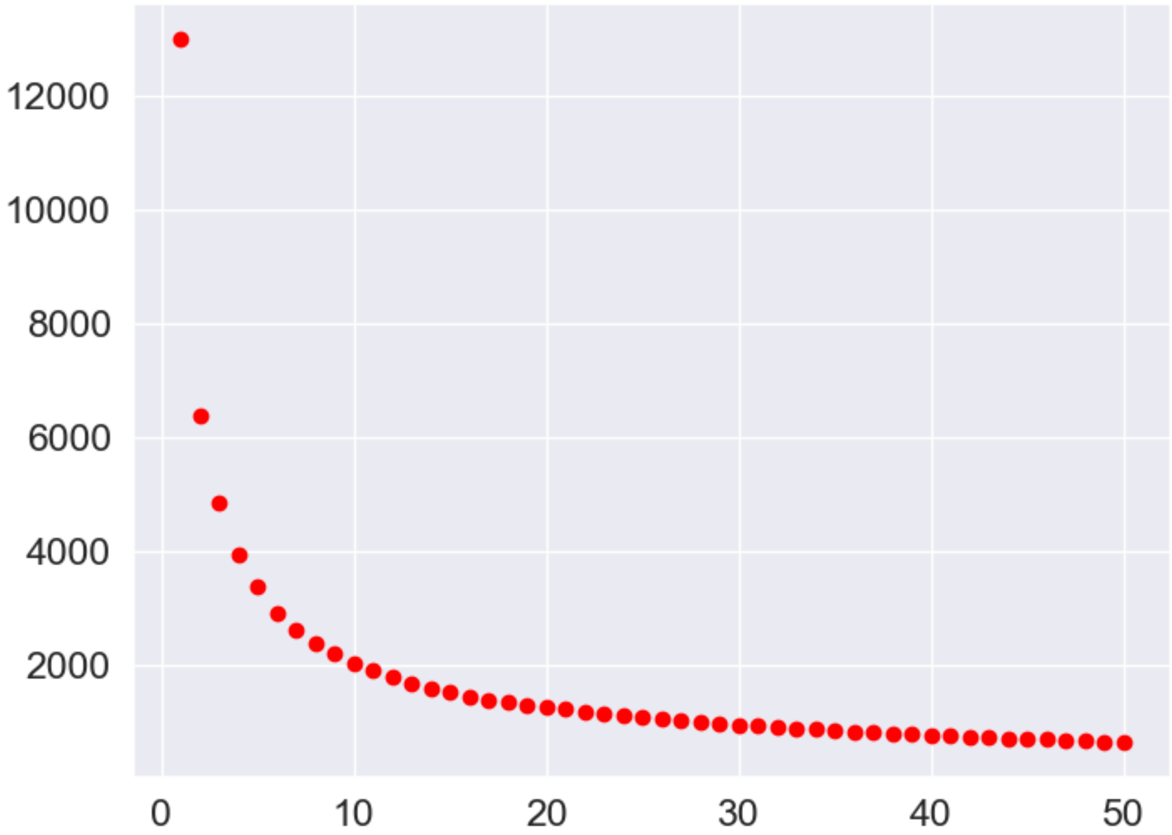
In [35]:
```
fig = plt.figure(figsize=(20,14))
f1 = fig.add_subplot(221); sns.regplot(x='recency', y='amount', data=customer_histo
f1 = fig.add_subplot(222); sns.regplot(x='frequency', y='amount', data=customer_his
f1 = fig.add_subplot(223); sns.regplot(x='recency_log', y='amount_log', data=custom
f1 = fig.add_subplot(224); sns.regplot(x='frequency_log', y='amount_log', data=cust

fig = plt.figure(figsize=(15, 10))
ax = fig.add_subplot(111, projection='3d')

xs =customer_history_df.recency_log
ys = customer_history_df.frequency_log
zs = customer_history_df.amount_log
ax.scatter(xs, ys, zs, s=5)

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

plt.show()
```



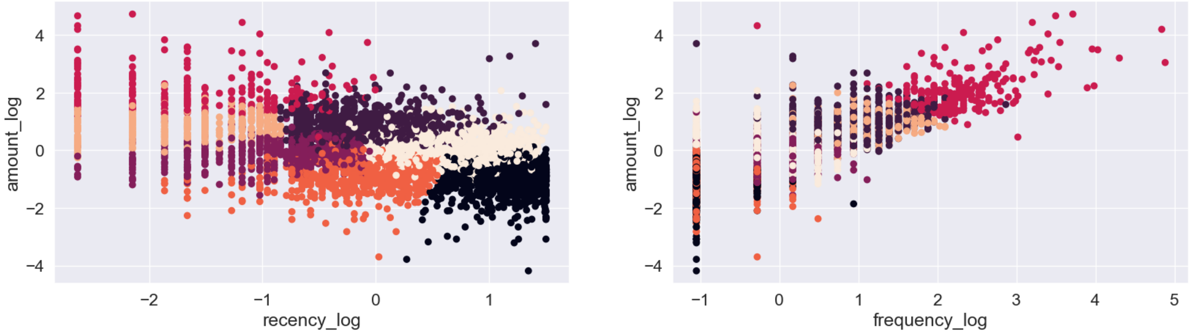

Recency
0
1
2
3
4
5
6
Frequency
0
1
2
3
4
5
Monetary
2
4
6
8
10
12

In [36]:

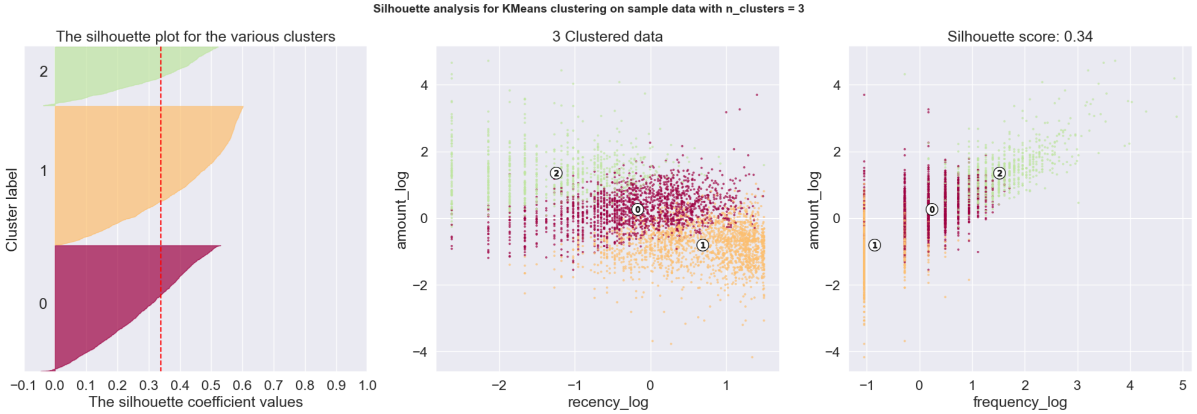
```
cl = 50
corte = 0.1

anterior = 100000000000000
cost = []
K_best = cl

for k in range (1, cl+1):
    # Create a kmeans model on our data, using k clusters.  random_state helps ensu
    model = KMeans(
        n_clusters=k,
        init='k-means++', #'random',
        n_init=10,
        max_iter=300,
        tol=1e-04,
        random_state=101)

    model = model.fit(X_scaled)

    # These are our fitted labels for clusters -- the first cluster has label 0, an
    labels = model.labels_

    # Sum of distances of samples to their closest cluster center
    interia = model.inertia_
    if (K_best == cl) and (((anterior - interia)/anterior) < corte): K_best = k - 1
    cost.append(interia)
    anterior = interia

plt.figure(figsize=(8, 6))
plt.scatter(range (1, cl+1), cost, c='red')
plt.show()

# Create a kmeans model with the best K.
print('The best K sugest: ',K_best)
model = KMeans(n_clusters=K_best, init='k-means++', n_init=10,max_iter=300, tol=1e-

# Note I'm scaling the data to normalize it! Important for good results.
model = model.fit(X_scaled)

# These are our fitted labels for clusters -- the first cluster has label 0, and th
labels = model.labels_

# And we'll visualize it:
#plt.scatter(X_scaled[:,0], X_scaled[:,1], c=model.labels_.astype(float))
fig = plt.figure(figsize=(20,5))
ax = fig.add_subplot(121)
plt.scatter(x = X_scaled[:,1], y = X_scaled[:,0], c=model.labels_.astype(float))
ax.set_xlabel(feature_vector[1])
ax.set_ylabel(feature_vector[0])
ax = fig.add_subplot(122)
plt.scatter(x = X_scaled[:,2], y = X_scaled[:,0], c=model.labels_.astype(float))
ax.set_xlabel(feature_vector[2])
ax.set_ylabel(feature_vector[0])

plt.show()
```

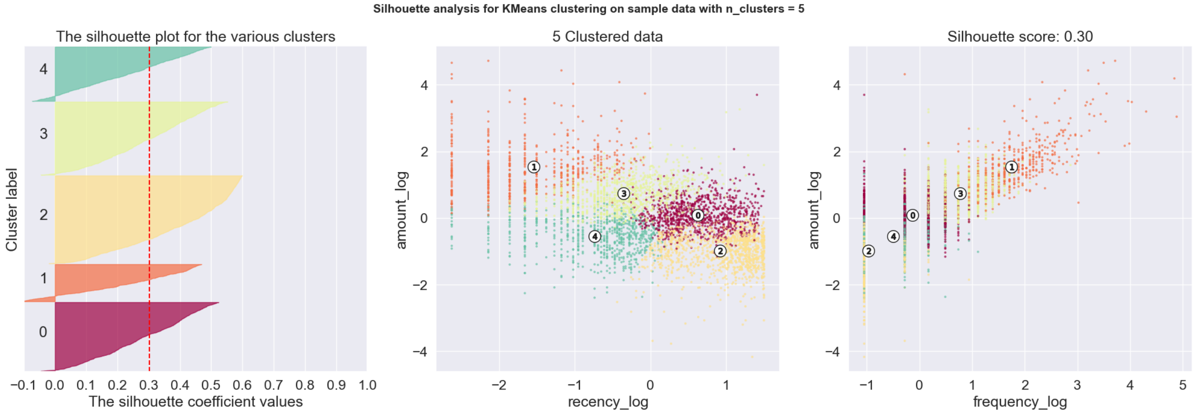


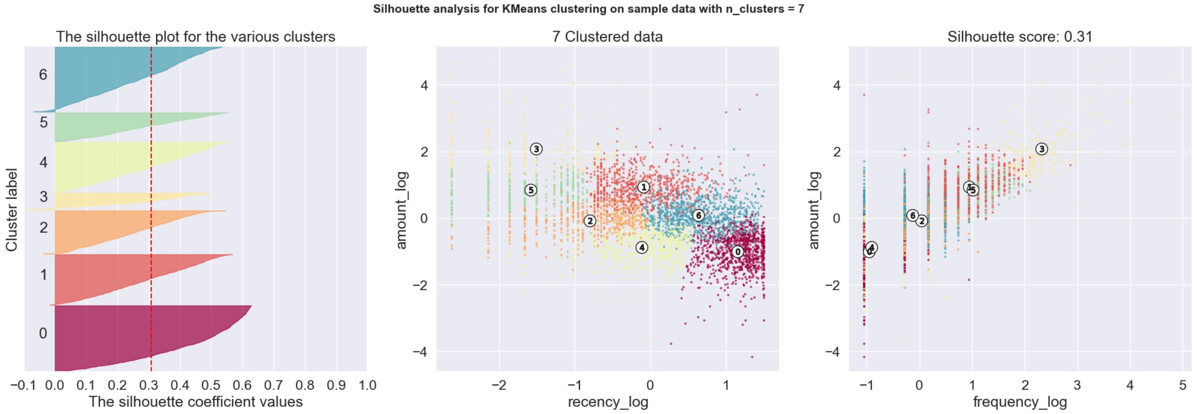
```
The best K sugest:  7
```



In [37]:
```
cluster_centers = dict()

for n_clusters in range(3,K_best+1,2):
    fig, (ax1, ax2, ax3) = plt.subplots(1, 3)
    fig.set_size_inches(25, 7)
    ax1.set_xlim([-0.1, 1])
    ax1.set_ylim([0, len(X_scaled) + (n_clusters + 1) * 10])

    clusterer = KMeans(n_clusters=n_clusters, init='k-means++', n_init=10,max_iter=
    cluster_labels = clusterer.fit_predict(X_scaled)

    silhouette_avg = silhouette_score(X = X_scaled, labels = cluster_labels)
    cluster_centers.update({n_clusters :{'cluster_center':clusterer.cluster_centers
                                         'silhouette_score':silhouette_avg,
                                         'labels':cluster_labels}
                           })

    sample_silhouette_values = silhouette_samples(X = X_scaled, labels = cluster_la
    y_lower = 10
    for i in range(n_clusters):
        ith_cluster_silhouette_values = sample_silhouette_values[cluster_labels ==

        ith_cluster_silhouette_values.sort()

        size_cluster_i = ith_cluster_silhouette_values.shape[0]
        y_upper = y_lower + size_cluster_i

        color = cm.Spectral(float(i) / n_clusters)
        ax1.fill_betweenx(np.arange(y_lower, y_upper),
                          0, ith_cluster_silhouette_values,
                          facecolor=color, edgecolor=color, alpha=0.7)

        ax1.text(-0.05, y_lower + 0.5 * size_cluster_i, str(i))
        y_lower = y_upper + 10  # 10 for the 0 samples

    ax1.set_title("The silhouette plot for the various clusters")
    ax1.set_xlabel("The silhouette coefficient values")
    ax1.set_ylabel("Cluster label")
    ax1.axvline(x=silhouette_avg, color="red", linestyle="--")
    ax1.set_yticks([])
    ax1.set_xticks([-0.1, 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1])
    colors = cm.Spectral(cluster_labels.astype(float) / n_clusters)

    centers = clusterer.cluster_centers_
    y = 0
    x = 1
    ax2.scatter(X_scaled[:, x], X_scaled[:, y], marker='.', s=30, lw=0, alpha=0.7,
    ax2.scatter(centers[:, x], centers[:, y], marker='o', c="white", alpha=1, s=200
    for i, c in enumerate(centers):
        ax2.scatter(c[x], c[y], marker='$%d$' % i, alpha=1, s=50, edgecolor='k')
    ax2.set_title("{} Clustered data".format(n_clusters))
    ax2.set_xlabel(feature_vector[x])
    ax2.set_ylabel(feature_vector[y])

    x = 2
    ax3.scatter(X_scaled[:, x], X_scaled[:, y], marker='.', s=30, lw=0, alpha=0.7,
    ax3.scatter(centers[:, x], centers[:, y], marker='o', c="white", alpha=1, s=200
    for i, c in enumerate(centers):
        ax3.scatter(c[x], c[y], marker='$%d$' % i, alpha=1, s=50, edgecolor='k')
        ax3.scatter(c[x], c[y], marker='$%d$' % i, alpha=1, s=50, edgecolor='k')
    ax3.set_title("Silhouette score: {:1.2f}".format(cluster_centers[n_clusters]['s
    ax3.set_xlabel(feature_vector[x])
    ax3.set_ylabel(feature_vector[y])

    plt.suptitle(("Silhouette analysis for KMeans clustering on sample data with n_
                 fontsize=14, fontweight='bold')
    plt.show()
```







In [38]:

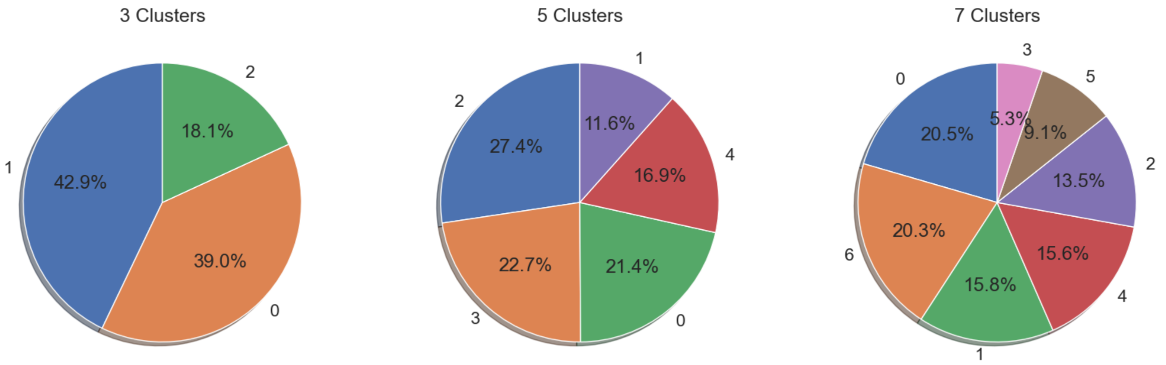
```
features = ['amount',  'recency',  'frequency']
for i in range(3,K_best+1,2):
    print("for {} clusters the silhouette score is {:1.2f}".format(i, cluster_cente
    print("Centers of each cluster:")
    cent_transformed = scaler.inverse_transform(cluster_centers[i]['cluster_center'
    print(pd.DataFrame(np.exp(cent_transformed),columns=features))
    print('-'*50)
```

```
for 3 clusters the silhouette score is 0.34
Centers of each cluster:
        amount     recency  frequency
0  1019.114007   33.637514   3.171771
1   262.853859  115.772727   1.196009
2  3983.322212    7.173427  10.099071
--------------------------------------------------
for 5 clusters the silhouette score is 0.30
Centers of each cluster:
        amount     recency  frequency
0   813.621211  105.524342   2.279822
1  5051.937209    4.728829  12.403678
2   208.013492  162.151056   1.075721
3  1830.850445   25.873099   5.126046
4   366.981282   15.050233   1.644625
--------------------------------------------------
for 7 clusters the silhouette score is 0.31
Centers of each cluster:
         amount     recency  frequency
0    205.487848  225.646442   1.084052
1   2401.476039   37.751906   6.002805
2    657.936736   13.675696   2.647270
3  10143.118638    4.926439  20.646017
4    239.411000   36.717710   1.130641
5   2114.266897    4.458579   6.365225
6    814.574493  107.556965   2.277767
--------------------------------------------------
```

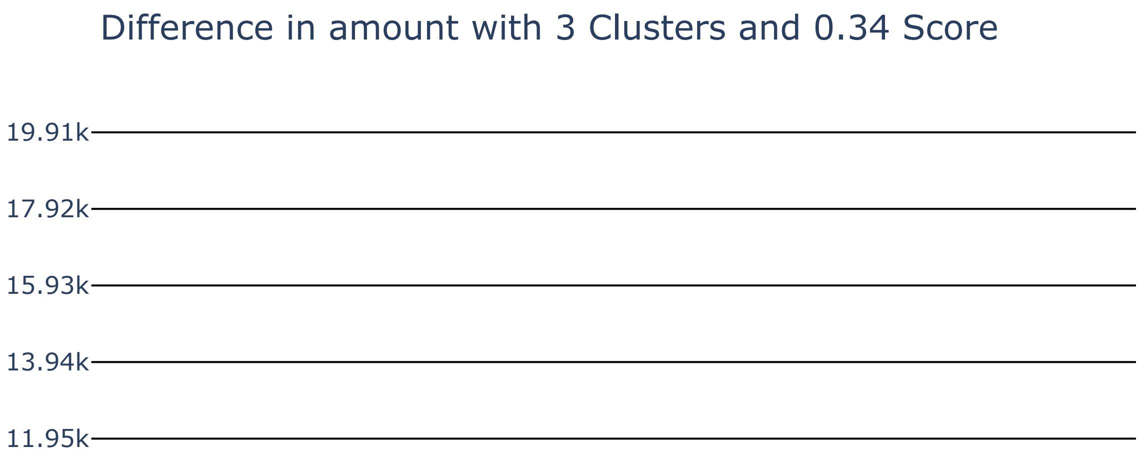
In [39]:

```python
customer_history_df['clusters_3'] = cluster_centers[3]['labels']
customer_history_df['clusters_5'] = cluster_centers[5]['labels']
customer_history_df['clusters_7'] = cluster_centers[7]['labels']
display(customer_history_df.head())

fig = plt.figure(figsize=(20,7))
f1 = fig.add_subplot(131)
market = customer_history_df.clusters_3.value_counts()
g = plt.pie(market, labels=market.index, autopct='%1.1f%%', shadow=True, startangle
plt.title('3 Clusters')
f1 = fig.add_subplot(132)
market = customer_history_df.clusters_5.value_counts()
g = plt.pie(market, labels=market.index, autopct='%1.1f%%', shadow=True, startangle
plt.title('5 Clusters')
f1 = fig.add_subplot(133)
market = customer_history_df.clusters_7.value_counts()
g = plt.pie(market, labels=market.index, autopct='%1.1f%%', shadow=True, startangle
plt.title('7 Clusters')
plt.show()
```

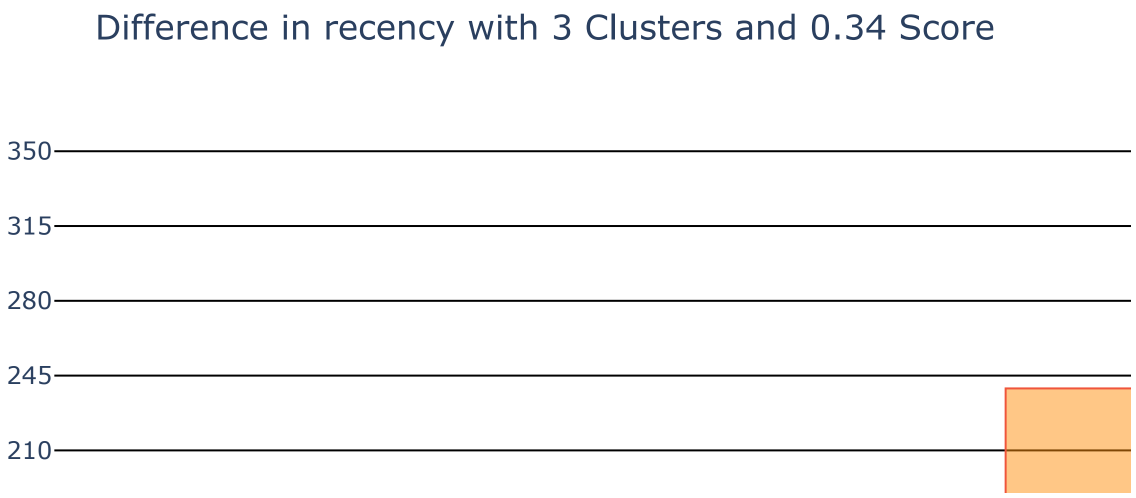
	CustomerID	recency	frequency	amount	recency_log	frequency_log	amount_log	clusters_3
0	12346	326.0	1	77183.60	5.786897	0.000000	11.253942	0
1	12347	2.0	7	4310.00	0.693147	1.945910	8.368693	2
2	12348	75.0	4	1797.24	4.317488	1.386294	7.494007	0
3	12349	19.0	1	1757.55	2.944439	0.000000	7.471676	0
4	12350	310.0	1	334.40	5.736572	0.000000	5.812338	1



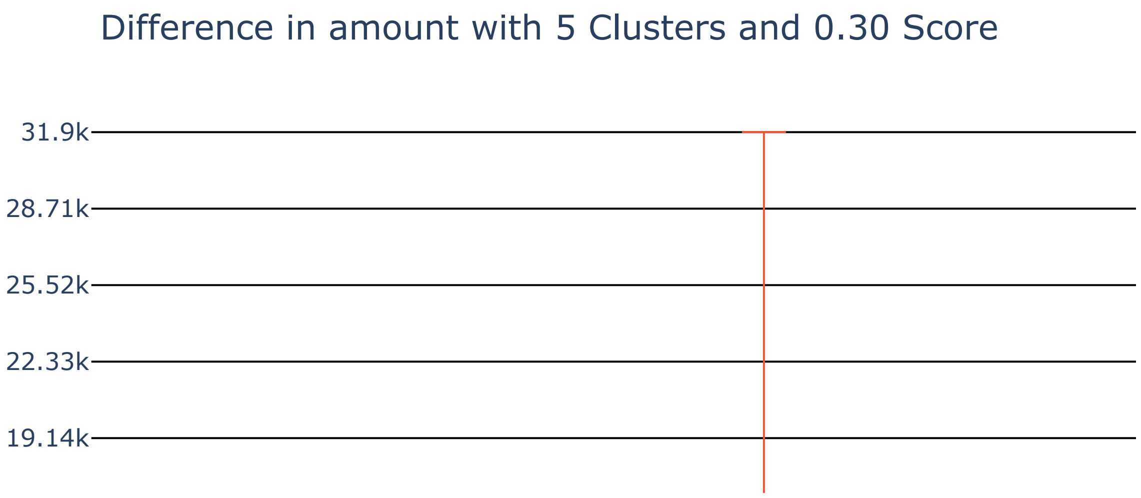
In [41]:
```
x_data = ['Cluster 0', 'Cluster 1','Cluster 2','Cluster 3','Cluster 4', 'Cluster 5'
colors = ['rgba(93, 164, 214, 0.5)', 'rgba(255, 144, 14, 0.5)', 'rgba(44, 160, 101,
          'rgba(22, 80, 57, 0.5)', 'rgba(127, 65, 14, 0.5)', 'rgba(207, 114, 255, 0
cutoff_quantile = 95

for n_clusters in range(3,K_best+1,2):
    cl = 'clusters_' + str(n_clusters)
    for fild in range(0, 3):
        field_to_plot = features[fild]
        y_data = list()
        ymax = 0
        for i in np.arange(0,n_clusters):
            y0 = customer_history_df[customer_history_df[cl]==i][field_to_plot].val
            y0 = y0[y0<np.percentile(y0, cutoff_quantile)]
            if ymax < max(y0): ymax = max(y0)
            y_data.insert(i, y0)

        traces = []

        for xd, yd, cls in zip(x_data[:n_clusters], y_data, colors[:n_clusters]):
                traces.append(go.Box(y=yd, name=xd, boxpoints=False, jitter=0.5, wh
                    marker=dict( size=1, ),
                    line=dict(width=1),
                ))

        layout = go.Layout(
            title='Difference in {} with {} Clusters and {:1.2f} Score'.\
            format(field_to_plot, n_clusters, cluster_centers[n_clusters]['silhouet
            yaxis=dict( autorange=True, showgrid=True, zeroline=True,
                dtick = int(ymax/10),
                gridcolor='black', gridwidth=0.1, zerolinecolor='rgb(255, 255, 255)
            margin=dict(l=40, r=30, b=50, t=50, ),
            paper_bgcolor='white',
            plot_bgcolor='white',
            showlegend=False
        )

        fig = go.Figure(data=traces, layout=layout)
        py.offline.iplot(fig)
```

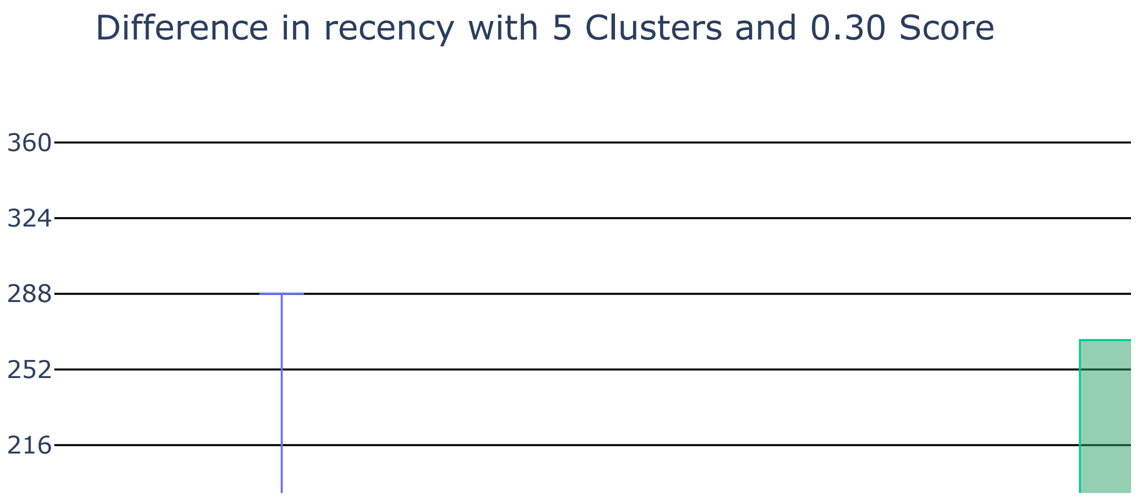


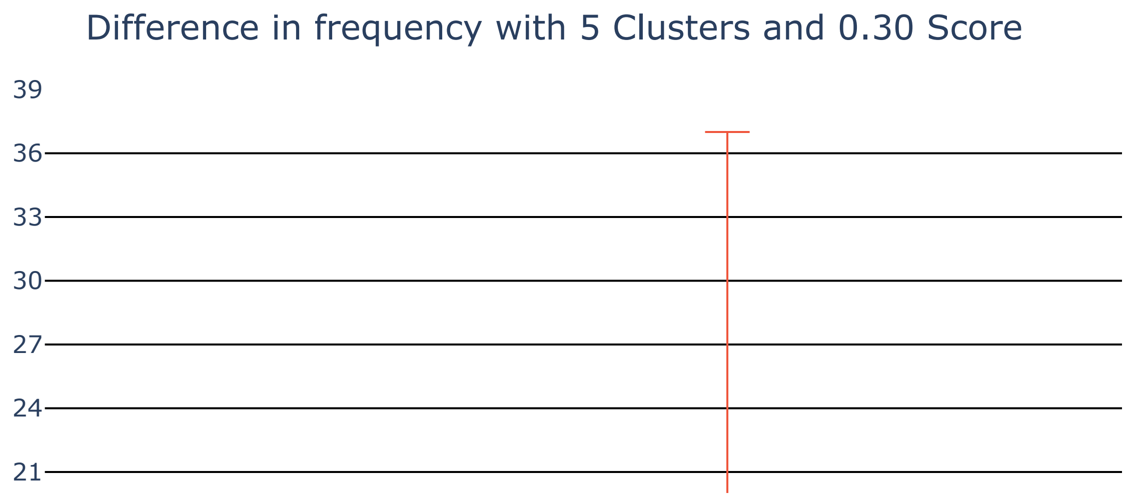
Difference in amount with 3 Clusters and 0.34 Score

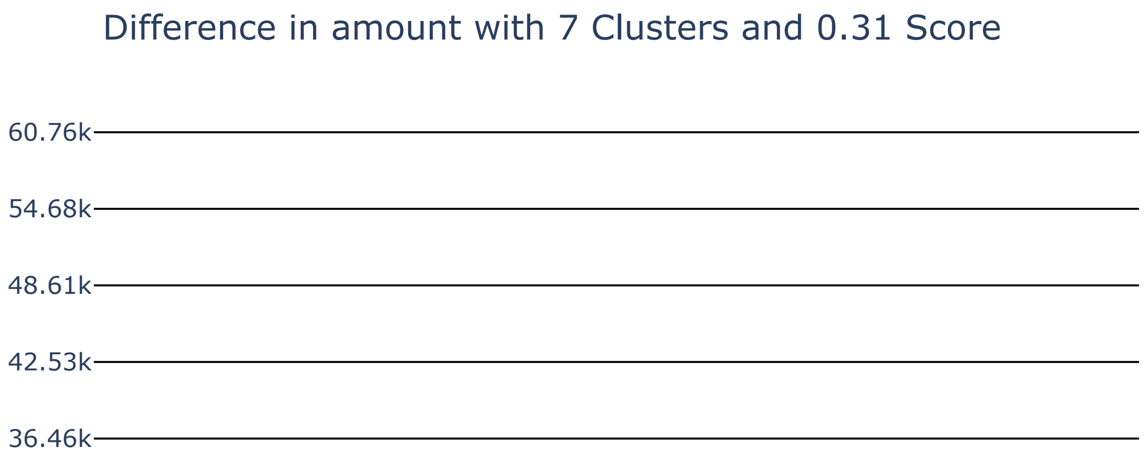

Difference in recency with 3 Clusters and 0.34 Score
350
315
280
245
210

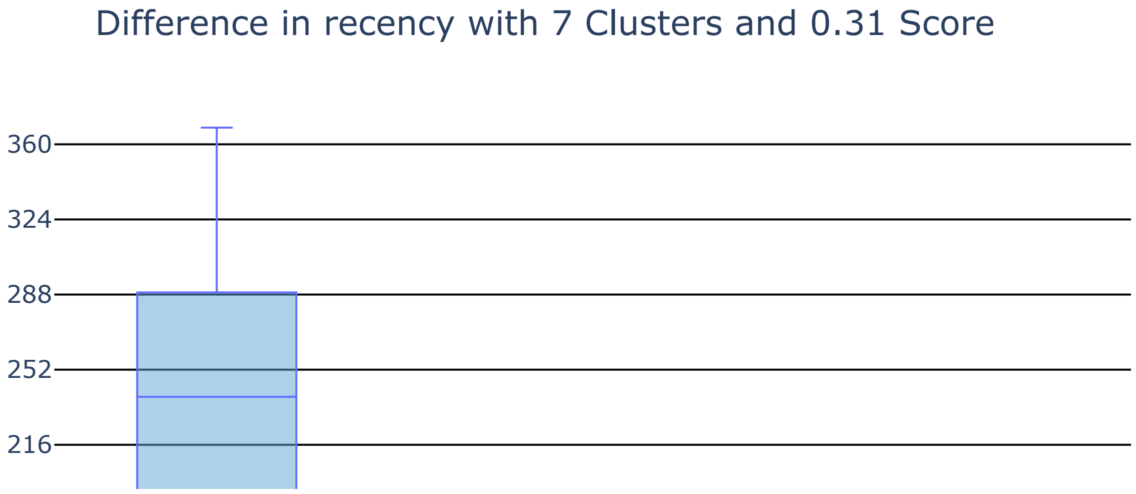
Difference in frequency with 3 Clusters and 0.34 Score

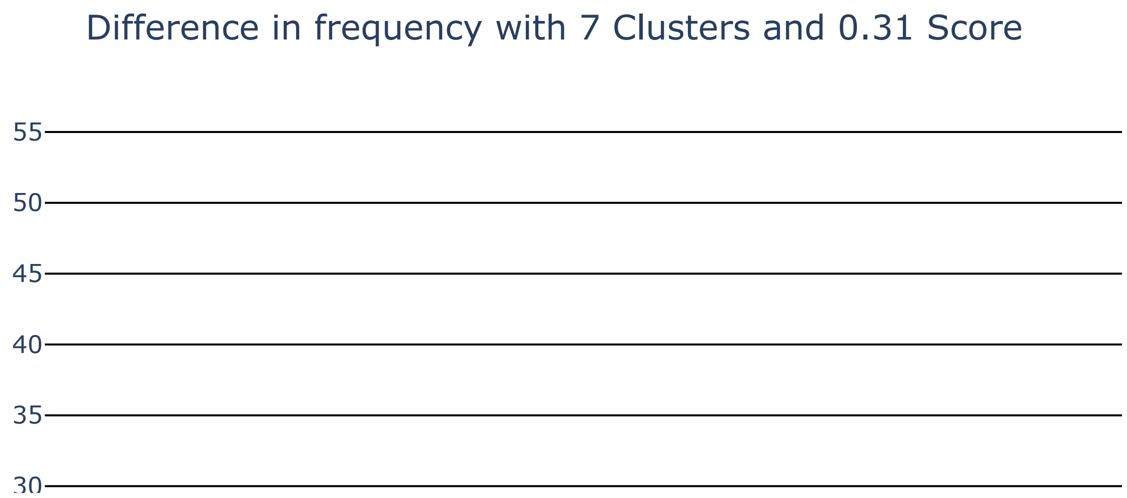

Difference in amount with 5 Clusters and 0.30 Score
31.9k
28.71k
25.52k
22.33k
19.14k


Difference in recency with 5 Clusters and 0.30 Score
360
324
288
252
216


Difference in frequency with 5 Clusters and 0.30 Score
39
36
33
30
27
24
21


Difference in amount with 7 Clusters and 0.31 Score
60.76k
54.68k
48.61k
42.53k
36.46k


Difference in recency with 7 Clusters and 0.31 Score
360
324
288
252
216



In [ ]:

```
items = list(cs_df.Description.unique())
grouped = cs_df.groupby('InvoiceNo')
transaction_level = grouped.aggregate(lambda x: tuple(x)).reset_index()[['InvoiceNo
transaction_dict = {item:0 for item in items}
output_dict = dict()
temp = dict()
for rec in transaction_level.to_dict('records'):
    invoice_num = rec['InvoiceNo']
    items_list = rec['Description']
    transaction_dict = {item:0 for item in items}
    transaction_dict.update({item:1 for item in items if item in items_list})
    temp.update({invoice_num:transaction_dict})

new = [v for k,v in temp.items()]
transaction_df = pd.DataFrame(new)
```

In [ ]:

```
def prune_dataset(input_df, length_trans = 2, total_sales_perc = 0.5,
                  start_item = None, end_item = None, TopCols = None):
    if 'total_items' in input_df.columns:
        del(input_df['total_items'])
    item_count = input_df.sum().sort_values(ascending = False).reset_index()
    total_items = sum(input_df.sum().sort_values(ascending = False))
    item_count.rename(columns={item_count.columns[0]:'item_name',
                               item_count.columns[1]:'item_count'}, inplace=True)
    if TopCols:
        input_df['total_items'] = input_df[TopCols].sum(axis = 1)
        input_df = input_df[input_df.total_items >= length_trans]
        del(input_df['total_items'])
        return input_df[TopCols], item_count[item_count.item_name.isin(TopCols)]
    elif end_item > start_item:
        selected_items = list(item_count[start_item:end_item].item_name)
        input_df['total_items'] = input_df[selected_items].sum(axis = 1)
        input_df = input_df[input_df.total_items >= length_trans]
        del(input_df['total_items'])
        return input_df[selected_items],item_count[start_item:end_item]
    else:
        item_count['item_perc'] = item_count['item_count']/total_items
        item_count['total_perc'] = item_count.item_perc.cumsum()
        selected_items = list(item_count[item_count.total_perc < total_sales_perc].
        input_df['total_items'] = input_df[selected_items].sum(axis = 1)
        input_df = input_df[input_df.total_items >= length_trans]
        del(input_df['total_items'])
        return input_df[selected_items], item_count[item_count.total_perc < total_s
```

In [44]:

```
output_df, item_counts = prune_dataset(input_df=transaction_df, length_trans=2,star
print('Total of Sales Amount by the Top 15 Products in Sales Events (Invoice): {:.2
print('Number of Sales Events:', output_df.shape[0])
print('Number of Products:', output_df.shape[1])

item_counts
```

```
Total of Sales Amount by the Top 15 Products in Sales Events (Invoice): 778377.21
Number of Sales Events: 4664
Number of Products: 15
```

Out[44]:

	item_name	item_count
0	WHITE HANGING HEART T-LIGHT HOLDER	1978
1	REGENCY CAKESTAND 3 TIER	1703
2	JUMBO BAG RED RETROSPOT	1600
3	PARTY BUNTING	1379
4	ASSORTED COLOUR BIRD ORNAMENT	1375
5	LUNCH BAG RED RETROSPOT	1289
6	SET OF 3 CAKE TINS PANTRY DESIGN	1146
7	POSTAGE	1099
8	JUMBO BAG VINTAGE DOILY	1080
9	LUNCH BAG BLACK SKULL.	1052
10	LUNCH BAG SUKI DESIGN	1043
11	POPCORN HOLDER	1035
12	PACK OF 72 RETROSPOT CAKE CASES	1029
13	SPOTTY BUNTING	1009
14	LUNCH BAG VINTAGE DOILY	1006

In [47]:

```
input_assoc_rules = output_df
# Defined the data domain by specifying each variable as a DiscreteVariable having
domain_transac = Domain([DiscreteVariable.make(name=item,values=['0', '1']) \
                         for item in input_assoc_rules.columns])

# Then using this domain, we created our Table structure for our data
data_tran = Orange.data.Table.from_numpy(domain=domain_transac,
                                         X=input_assoc_rules.as_matrix(),Y= None)

# Coding our input so that the entire domain is represented as binary variables
data_tran_en, mapping = OneHot.encode(data_tran, include_class=True)
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
Cell In[47], line 8
      3 domain_transac = Domain([DiscreteVariable.make(name=item,values=['0', '1'])
\
      4                           for item in input_assoc_rules.columns])
      6 # Then using this domain, we created our Table structure for our data
      7 data_tran = Orange.data.Table.from_numpy(domain=domain_transac,
----> 8                                           X=input_assoc_rules.as_matrix(),Y=
None)
     10 # Coding our input so that the entire domain is represented as binary varia
bles
     11 data_tran_en, mapping = OneHot.encode(data_tran, include_class=True)

File C:\ProgramData\anaconda3\lib\site-packages\pandas\core\generic.py:5902, in NDF
rame.__getattr__(self, name)
   5895 if (
   5896     name not in self._internal_names_set
   5897     and name not in self._metadata
   5898     and name not in self._accessors
   5899     and self._info_axis._can_hold_identifiers_and_holds_name(name)
   5900 ):
   5901     return self[name]
-> 5902 return object.__getattribute__(self, name)

AttributeError: 'DataFrame' object has no attribute 'as_matrix'
```

In [ ]:

```
support = 0.01
print("num of required transactions = ", int(input_assoc_rules.shape[0]*support))
num_trans = input_assoc_rules.shape[0]*support
itemsets = dict(frequent_itemsets(data_tran_en, support))
print('Items Set Size:', len(itemsets))
```

In [ ]:

```
confidence = 0.6
rules_df = pd.DataFrame()
if len(itemsets) < 1000000:
    rules = [(P, Q, supp, conf)
    for P, Q, supp, conf in association_rules(itemsets, confidence)
       if len(Q) == 1 ]

    names = {item: '{}={}'.format(var.name, val)
        for item, var, val in OneHot.decode(mapping, data_tran, mapping)}

    eligible_ante = [v for k,v in names.items() if v.endswith("1")]

    N = input_assoc_rules.shape[0]

    rule_stats = list(rules_stats(rules, itemsets, N))

    rule_list_df = []
    for ex_rule_frm_rule_stat in rule_stats:
        ante = ex_rule_frm_rule_stat[0]
        cons = ex_rule_frm_rule_stat[1]
        named_cons = names[next(iter(cons))]
        if named_cons in eligible_ante:
            rule_lhs = [names[i][:-2] for i in ante if names[i] in eligible_ante]
            ante_rule = ', '.join(rule_lhs)
            if ante_rule and len(rule_lhs)>1 :
                rule_dict = {'support' : ex_rule_frm_rule_stat[2],
                             'confidence' : ex_rule_frm_rule_stat[3],
                             'coverage' : ex_rule_frm_rule_stat[4],
                             'strength' : ex_rule_frm_rule_stat[5],
                             'lift' : ex_rule_frm_rule_stat[6],
                             'leverage' : ex_rule_frm_rule_stat[7],
                             'antecedent': ante_rule,
                             'consequent':named_cons[:-2] }
                rule_list_df.append(rule_dict)
    rules_df = pd.DataFrame(rule_list_df)
    print("Raw rules data frame of {} rules generated".format(rules_df.shape[0]))
    if not rules_df.empty:
        pruned_rules_df = rules_df.groupby(['antecedent','consequent']).max().reset
    else:
        print("Unable to generate any rule")
```

In [ ]: