ADS505 Final Project

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```
#Import Libraries
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.decomposition import PCA
from sklearn.cluster import KMeans
from sklearn.datasets import make_blobs
from yellowbrick.cluster import KElbowVisualizer
from sklearn.cluster import MiniBatchKMeans
from sklearn.linear_model import LogisticRegression, LogisticRegressionCV
from dmba import classificationSummary, gainsChart, liftChart, plotDecisionTree
from dmba.metric import AIC_score
import numpy as np
import pandas as pd
import sklearn.cluster as cluster
import scipy.spatial.distance as sdist
from sklearn import svm
from sklearn import metrics
from sklearn.metrics import accuracy_score
import pandas
import matplotlib.pyplot as plt
from sklearn import model_selection
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.naive_bayes import GaussianNB
from sklearn.svm import SVC
```

Import marketing campaign dataset for customer personality analysis.

```
#import dataset
df = pd.read_csv('marketing_campaign.csv')
df
```

	ID int64 0 – 11191	Year_Birth int64 1893 – 1996	Education object Graduation 50.3% PhD 21.7% 3 others 28%	Marital_Status object Married 38.6% Together 25.9% 6 others 35.5%	Income float64 1730.0 – 666666.0	Kidhome int64 0 – 2	Teenhome int64 0 – 2	Dt_Customer object 31-08-2012 0.5% 12/5/2014 0.5% 661 others 99%	Recency int64 0 – 99	MntWines 0 – 1493
0	5524	1957	Graduation	Single	58138	0	0	4/9/2012	58	635
1	2174	1954	Graduation	Single	46344	1	1	8/3/2014	38	11
2	4141	1965	Graduation	Together	71613	0	0	21-08-2013	26	426
3	6182	1984	Graduation	Together	26646	1	0	10/2/2014	26	11
4	5324	1981	PhD	Married	58293	1	0	19-01-2014	94	173
Expand rows 5 - 2234										
2235	10870	1967	Graduation	Married	61223	0	1	13-06-2013	46	709
2236	4001	1946	PhD	Together	64014	2	1	10/6/2014	56	406
2237	7270	1981	Graduation	Divorced	56981	0	0	25-01-2014	91	908
2238	8235	1956	Master	Together	69245	0	1	24-01-2014	8	428
2239	9405	1954	PhD	Married	52869	1	1	15-10-2012	40	84

2240 rows × 29 columns

```
#Glance at the dataset
df.head()
df.shape
```

```
(2240, 29)
```

```
# View fields with nan values.
df.isna().sum()
```

```
ID                     0
Year_Birth             0
Education              0
Marital_Status         0
Income                24
Kidhome                0
Teenhome               0
Dt_Customer            0
Recency                0
MntWines               0
MntFruits              0
MntMeatProducts        0
MntFishProducts        0
MntSweetProducts       0
MntGoldProds           0
NumDealsPurchases      0
NumWebPurchases        0
NumCatalogPurchases    0
NumStorePurchases      0
NumWebVisitsMonth      0
AcceptedCmp3           0
AcceptedCmp4           0
AcceptedCmp5           0
AcceptedCmp1           0
AcceptedCmp2           0
Complain               0
Z_CostContact          0
Z_Revenue              0
Response               0
dtype: int64
```

Drop records with NAs due to there only being 24 in Income field and it does not change the overall dataset.

```
# Drop records with nan values.
df = df.dropna()
df.shape
```

```
(2216, 29)
```

```
#Create a Column to see the total amount of money spent
df['TotalAmountSpent'] = df['MntWines'] + df['MntFruits'] + df['MntMeatProducts'] + df['MntSweetProducts'] + df['MntGoldProds']
df['TotalAmountSpent'].head()
```

```
/shared-libs/python3.7/py-core/lib/python3.7/site-packages/ipykernel_launcher.py:2: 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
```

```
0    1445
1      25
2     665
3      43
4     376
Name: TotalAmountSpent, dtype: int64
```

```
df['TotalNumPurchases'] = df['NumWebPurchases'] + df['NumDealsPurchases'] + df['NumCatalogPurchases'] + df['NumStorePurchases']
df['TotalNumPurchases'].head()
```

```
/shared-libs/python3.7/py-core/lib/python3.7/site-packages/ipykernel_launcher.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
  """Entry point for launching an IPython kernel.
```

```
0    25
1     6
2    21
3     8
4    19
Name: TotalNumPurchases, dtype: int64
```

```
df['Avg_Spent_PP'] = (df['TotalAmountSpent'] / df['TotalNumPurchases']
df['Avg_Spent_PP'] = df['Avg_Spent_PP'].round(2)
df['Avg_Spent_PP']
```

```
/shared-libs/python3.7/py-core/lib/python3.7/site-packages/ipykernel_launcher.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
  """Entry point for launching an IPython kernel.
/shared-libs/python3.7/py-core/lib/python3.7/site-packages/ipykernel_launcher.py:2: 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
```

```
0       57.80
1        4.17
2       31.67
3        5.38
4       19.79
        ...
2235    72.17
2236    20.18
2237    63.63
2238    33.17
2239    15.45
Name: Avg_Spent_PP, Length: 2216, dtype: float64
```

```
#Combine both Kidhome and Teenhome
df['ChildrenAtHome'] = df['Kidhome'] + df['Teenhome']
df['ChildrenAtHome'].head()
```

```
/shared-libs/python3.7/py-core/lib/python3.7/site-packages/ipykernel_launcher.py:2: 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
```

```
0    0
1    2
2    0
3    1
4    1
Name: ChildrenAtHome, dtype: int64
```

```
df.head()
```

	ID int64	Year_Birth int64	Education object	Marital_Status object	Income float64	Kidhome int64	Teenhome int64	Dt_Customer object	Recency int64	MntWines int64	Mn
0	5524	1957	Graduation	Single	58138	0	0	4/9/2012	58	635	88
1	2174	1954	Graduation	Single	46344	1	1	8/3/2014	38	11	1
2	4141	1965	Graduation	Together	71613	0	0	21-08-2013	26	426	49

	ID int64	Year_Birth int64	Education object	Marital_Status object	Income float64	Kidhome int64	Teenhome int64	Dt_Customer object	Recency int64	MntWines int64	Mnt
3	6182	1984	Graduation	Together	26646	1	0	10/2/2014	26	11	4
4	5324	1981	PhD	Married	58293	1	0	19-01-2014	94	173	43

5 rows × 31 columns

```
#df[['Education', 'Marital_Status', 'Income', 'ChildrenAtHome']].apply(lambda x: x.astype('category'))
```

```
#cols = ['Education', 'Marital_Status', 'Income', 'ChildrenAtHome']
#df[cols] = df[cols].astype('category')
```

```
#df.head()
```

```
df['Education'].value_counts()
```

```
Graduation    1116
PhD            481
Master         365
2n Cycle       200
Basic           54
Name: Education, dtype: int64
```

```
#Changes Education into Basic and Advanced
df['Education'].replace({"Graduation":"Advanced", "PhD":"Advanced", "Master":"Advanced", "2n Cycle":"Basic"}, inplace=True)
df['Education'].replace({"Advanced":1,"Basic":0}, inplace = True)
df['Education'].value_counts()
```

```
/shared-libs/python3.7/py/lib/python3.7/site-packages/pandas/core/series.py:4515: 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
  method=method,
```

```
1    1962
0     254
Name: Education, dtype: int64
```

```
df['Marital_Status'].value_counts()
```

```
Married     857
Together    573
Single      471
Divorced    232
Widow        76
Alone         3
YOLO          2
Absurd        2
Name: Marital_Status, dtype: int64
```

```
#Change Marital Status
df['Marital_Status'].replace({"Absurd":"Single", "YOLO":"Single", "Alone":"Single", "Widow":"Single", "Divorced":"Single", "Together":"Not Single", "Marrie
df['Marital_Status'].value_counts()
df['Marital_Status'].replace({"Not Single":1,"Single":0}, inplace = True)
df['Marital_Status'].value_counts()
```

```
/shared-libs/python3.7/py/lib/python3.7/site-packages/pandas/core/series.py:4515: 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
  method=method,
```

```
1    1430
0     786
Name: Marital_Status, dtype: int64
```

```
df['Income'].value_counts()
```

```
7500.0     12
35860.0     4
18929.0     3
34176.0     3
67445.0     3
           ..
83033.0     1
29999.0     1
65819.0     1
54132.0     1
62335.0     1
Name: Income, Length: 1974, dtype: int64
```

```
df['ChildrenAtHome'].value_counts()
```

```
1    1117
0     633
2     416
3      50
Name: ChildrenAtHome, dtype: int64
```

```
conditions = [
    (df['ChildrenAtHome'] <= 0),
    (df['ChildrenAtHome'] > 0) ,
    ]
values = ['NO', 'YES']
df['Children'] = np.select(conditions, values)
```

```
/shared-libs/python3.7/py-core/lib/python3.7/site-packages/ipykernel_launcher.py:6: 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
```

```
df['Children'].replace({"YES":1,"NO":0}, inplace = True)
df['Children'].value_counts()
```

```
/shared-libs/python3.7/py/lib/python3.7/site-packages/pandas/core/series.py:4515: 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
  method=method,
```

```
1    1583
0     633
Name: Children, dtype: int64
```

```
Income_conditions = [
    (df['Income'] <= 10000.0),
    (df['Income'] > 10000.0) & (df['Income'] <= 40000.0),
    (df['Income'] > 40000.0) & (df['Income'] <= 70000.0),
    (df['Income'] > 70000.0) & (df['Income'] <= 100000.0),
    (df['Income'] > 100000.0)
    ]
Income_values = ['1', '2', '3', '4', '5']
df['Income_tier'] = np.select(Income_conditions, Income_values)
```

```
/shared-libs/python3.7/py-core/lib/python3.7/site-packages/ipykernel_launcher.py:9: 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
  if __name__ == '__main__':
```

```
df['Income_tier'].value_counts()
```

```
3    976
2    703
4    495
1     29
5     13
Name: Income_tier, dtype: int64
```

```
df.head()
```

	ID int64	Year_Birth int64	Education object	Marital_Status object	Income float64	Kidhome int64	Teenhome int64	Dt_Customer object	Recency int64	MntWines int64	Mnt
0	5524	1957	Advanced	Single	58138	0	0	4/9/2012	58	635	88
1	2174	1954	Advanced	Single	46344	1	1	8/3/2014	38	11	1
2	4141	1965	Advanced	Not Single	71613	0	0	21-08-2013	26	426	49
3	6182	1984	Advanced	Not Single	26646	1	0	10/2/2014	26	11	4
4	5324	1981	Advanced	Not Single	58293	1	0	19-01-2014	94	173	43

5 rows × 33 columns

```
df['TotalAmountSpent'].value_counts()
```

```
21      19
51      17
54      17
45      16
37      16
        ..
698      1
215      1
702      1
2260     1
6        1
Name: TotalAmountSpent, Length: 995, dtype: int64
```

```
total_conditions = [
    (df['TotalAmountSpent'] <= 100.0),
    (df['TotalAmountSpent'] > 100.0) & (df['TotalAmountSpent'] <= 400.0),
    (df['TotalAmountSpent'] > 400.0) & (df['TotalAmountSpent'] <= 700.0),
    (df['TotalAmountSpent'] > 700.0) & (df['TotalAmountSpent'] <= 1000.0),
    (df['TotalAmountSpent'] > 1000.0)
    ]
total_values = ['1', '2', '3', '4', '5']
df['Total_tier'] = np.select(total_conditions, total_values)
```

```
/shared-libs/python3.7/py-core/lib/python3.7/site-packages/ipykernel_launcher.py:9: 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
  if __name__ == '__main__':
```

```
df['Total_tier'].value_counts()
```

```
1    732
5    526
2    416
4    274
3    268
Name: Total_tier, dtype: int64
```

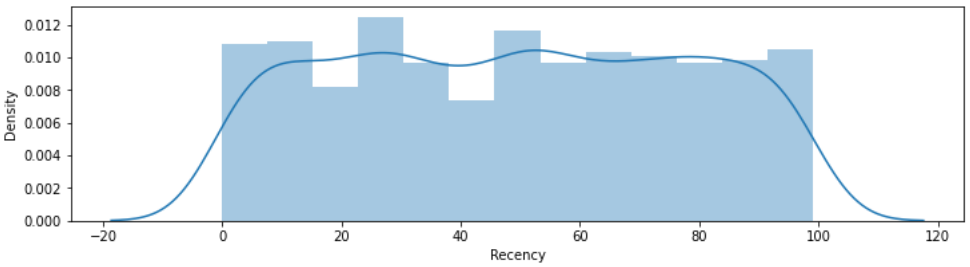
```
df.head()
```

	ID int64	Year_Birth int64	Education object	Marital_Status object	Income float64	Kidhome int64	Teenhome int64	Dt_Customer object	Recency int64	MntWines int64	Mnt
0	5524	1957	Advanced	Single	58138	0	0	4/9/2012	58	635	88
1	2174	1954	Advanced	Single	46344	1	1	8/3/2014	38	11	1
2	4141	1965	Advanced	Not Single	71613	0	0	21-08-2013	26	426	49
3	6182	1984	Advanced	Not Single	26646	1	0	10/2/2014	26	11	4
4	5324	1981	Advanced	Not Single	58293	1	0	19-01-2014	94	173	43

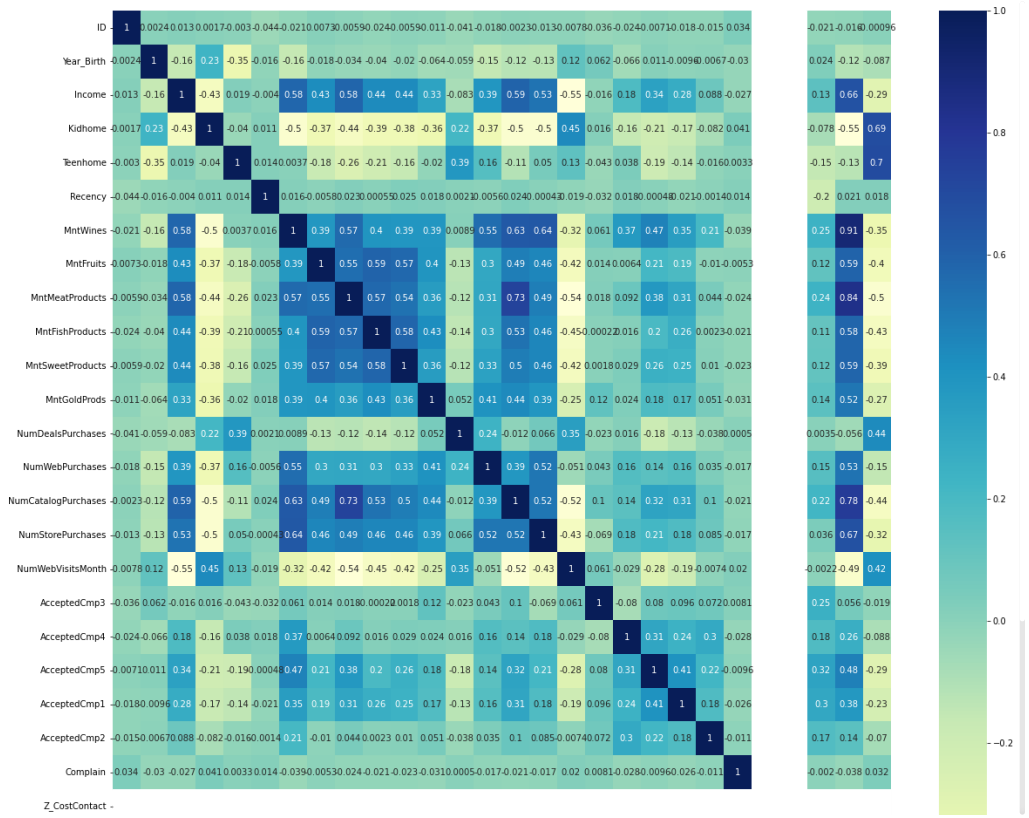
5 rows × 36 columns

```
#Plot of recency
plt.figure(figsize=(12,10))
plt.subplot(3, 1, 1); sns.distplot(df['Recency'])
plt.show()
```

```
/shared-libs/python3.7/py/lib/python3.7/site-packages/seaborn/distributions.py:2619: FutureWarning: `distplot` is a deprecated function and will be removed in a future version. Plea
  warnings.warn(msg, FutureWarning)
```




```
fig, ax = plt.subplots(figsize=(20,20))
fig = sns.heatmap(df.corr(), cmap="YlGnBu", annot=True)
plt.show()
```



```
df['Age'] = 2021 - df['Year_Birth']
df
```

```
/shared-libs/python3.7/py-core/lib/python3.7/site-packages/ipykernel_launcher.py:1: SettingWithCopyWarning:
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  """Entry point for launching an IPython kernel.
```

	ID int64 0 – 11191	Year_Birth int64 1893 – 1996	Education float64 0.0 – 1.0	Marital_Status int64 0 – 1	Income float64 1730.0 – 666666.0	Kidhome int64 0 – 2	Teenhome int64 0 – 2	Dt_Customer object 31-08-2012 0.5% 12/5/2014 0.5% 660 others 99%	Recency int64 0 – 99	MntWines 0 – 1493
0	5524	1957	1	0	58138	0	0	4/9/2012	58	635
1	2174	1954	1	0	46344	1	1	8/3/2014	38	11
2	4141	1965	1	1	71613	0	0	21-08-2013	26	426
3	6182	1984	1	1	26646	1	0	10/2/2014	26	11
4	5324	1981	1	1	58293	1	0	19-01-2014	94	173
Expand rows 5 - 2210										
2235	10870	1967	1	1	61223	0	1	13-06-2013	46	709
2236	4001	1946	1	1	64014	2	1	10/6/2014	56	406
2237	7270	1981	1	0	56981	0	0	25-01-2014	91	908
2238	8235	1956	1	1	69245	0	1	24-01-2014	8	428
2239	9405	1954	1	1	52869	1	1	15-10-2012	40	84

2216 rows × 38 columns

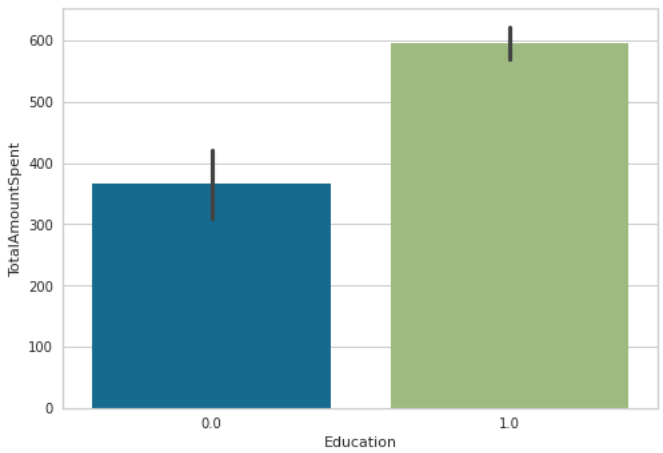
```
df['Education'] = df['Education'].astype(np.float64)
```

```
/shared-libs/python3.7/py-core/lib/python3.7/site-packages/ipykernel_launcher.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
  """Entry point for launching an IPython kernel.
```

```
sns.barplot(df['Education'],df['TotalAmountSpent'])
```

```
/shared-libs/python3.7/py/lib/python3.7/site-packages/seaborn/_decorators.py:43: FutureWarning: Pass the following variables as keyword args: x, y. From version 0.12, the only valid
  FutureWarning
```

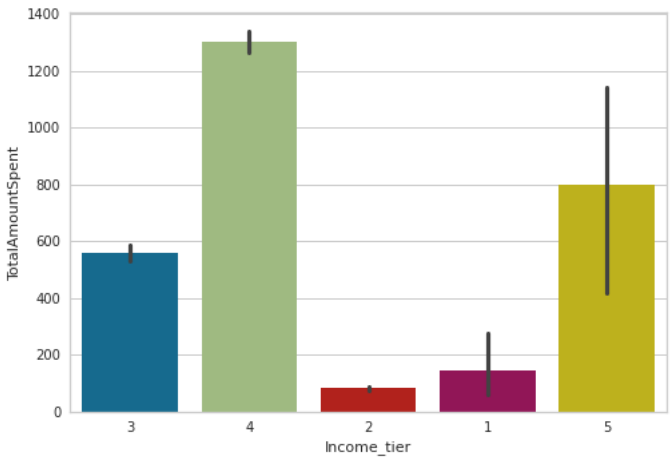
```
<AxesSubplot:xlabel='Education', ylabel='TotalAmountSpent'>
```



```
sns.barplot(df['Income_tier'],df['TotalAmountSpent'])
```

```
/shared-libs/python3.7/py/lib/python3.7/site-packages/seaborn/_decorators.py:43: FutureWarning: Pass the following variables as keyword args: x, y. From version 0.12, the only valid
  FutureWarning
```

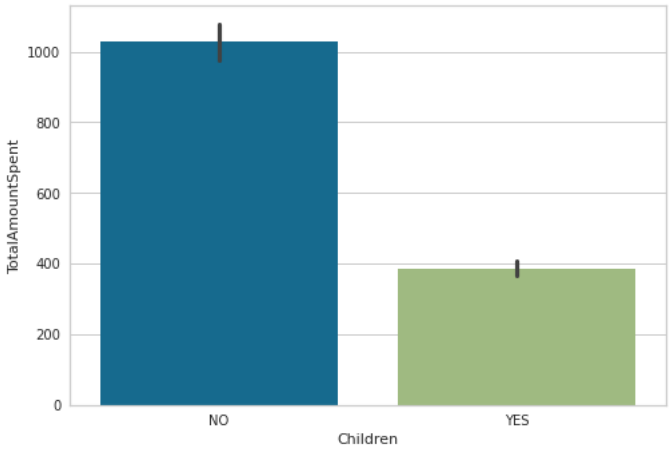
```
<AxesSubplot:xlabel='Income_tier', ylabel='TotalAmountSpent'>
```




```
sns.barplot(df['Children'],df['TotalAmountSpent'])
```

```
/shared-libs/python3.7/py/lib/python3.7/site-packages/seaborn/_decorators.py:43: FutureWarning: Pass the following variables as keyword args: x, y. From version 0.12, the only valid
  FutureWarning
```

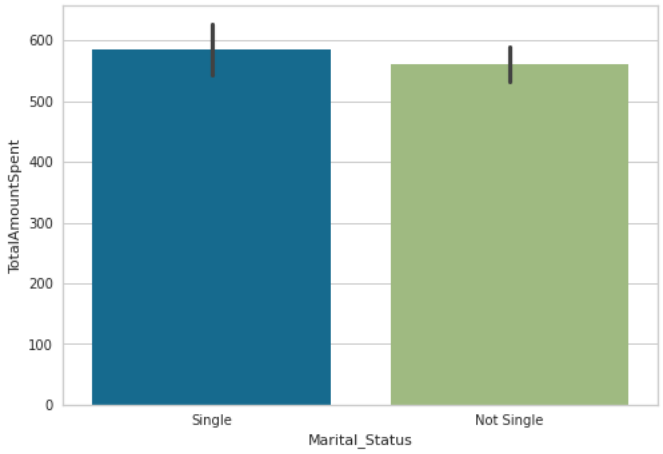
```
<AxesSubplot:xlabel='Children', ylabel='TotalAmountSpent'>
```




```
sns.barplot(df['Marital_Status'],df['TotalAmountSpent'])
```

```
/shared-libs/python3.7/py/lib/python3.7/site-packages/seaborn/_decorators.py:43: FutureWarning: Pass the following variables as keyword args: x, y. From version 0.12, the only valid
  FutureWarning
```

```
<AxesSubplot:xlabel='Marital_Status', ylabel='TotalAmountSpent'>
```




```
del_cols = ['ID', 'Avg_Spent_PP', 'Year_Birth', 'Income','Dt_Customer','MntWines', 'MntFruits', 'MntMeatProducts', 'MntFishProducts', 'AcceptedCmp4', 'Acce
ds = df.drop(del_cols, axis=1)
scaler = StandardScaler()
scaler.fit(ds)
scaled_features = pd.DataFrame(scaler.transform(ds),columns= ds.columns )
```

```
ds.isna().sum()
ds
```

	Education float64 0.0 – 1.0	Marital_Status int64 0 – 1	Kidhome int64 0 – 2	Teenhome int64 0 – 2	Recency int64 0 – 99	MntSweetProducts int64 0 – 262	MntGoldProds int64 0 – 321	NumDealsPurchases int64 0 – 15	NumWebPur 0 – 27
0	1	0	0	0	58	88	88	3	8
1	1	0	1	1	38	1	6	2	1
2	1	1	0	0	26	21	42	1	8
3	1	1	1	0	26	3	5	2	2
4	1	1	1	0	94	27	15	5	5
Expand rows 5 - 2210									
2235	1	1	0	1	46	118	247	2	9
2236	1	1	2	1	56	0	8	7	8
2237	1	0	0	0	91	12	24	1	2
2238	1	1	0	1	8	30	61	2	6
2239	1	1	1	1	40	1	21	3	3

2216 rows × 24 columns

```
ds['Total_tier'] = ds['Total_tier'].astype(str).astype(int)
ds['Income_tier'] = ds['Income_tier'].astype(str).astype(int)
```

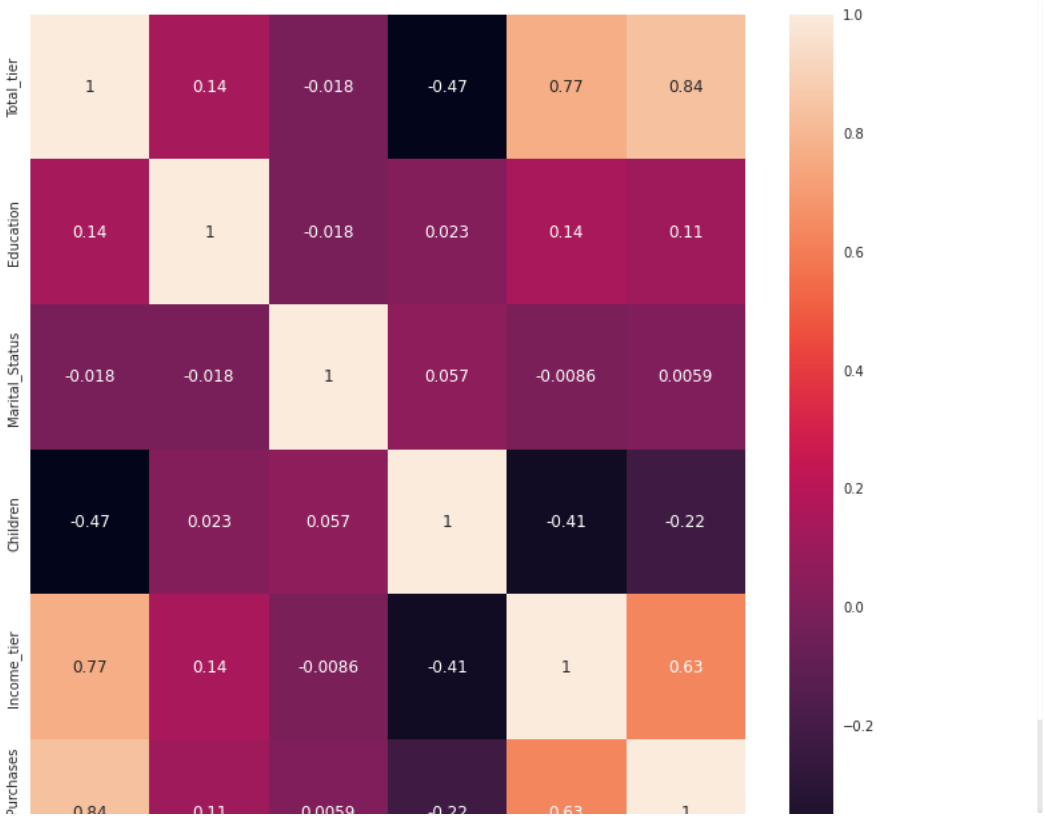
```
# Subset of df dataframe: Dimension reduction for desired predictors
ds_sub = ds[['Total_tier','Education','Marital_Status',
             'Children','Income_tier','TotalNumPurchases']]
ds_sub.head()
```

	Total_tier int64	Education float64	Marital_Status int64	Children int64	Income_tier int64	TotalNumPurchases int64
0	5	1	0	0	3	25
1	1	1	0	1	3	6
2	3	1	1	0	4	21
3	1	1	1	1	2	8

	Total_tier int64	Education float64	Marital_Status int64	Children int64	Income_tier int64	TotalNumPurchases int64
4	2	1	1	1	3	19

5 rows × 6 columns

```
plt.figure(figsize=(12,12))
sns.heatmap(ds_sub.corr(), annot=True)
plt.show()
```



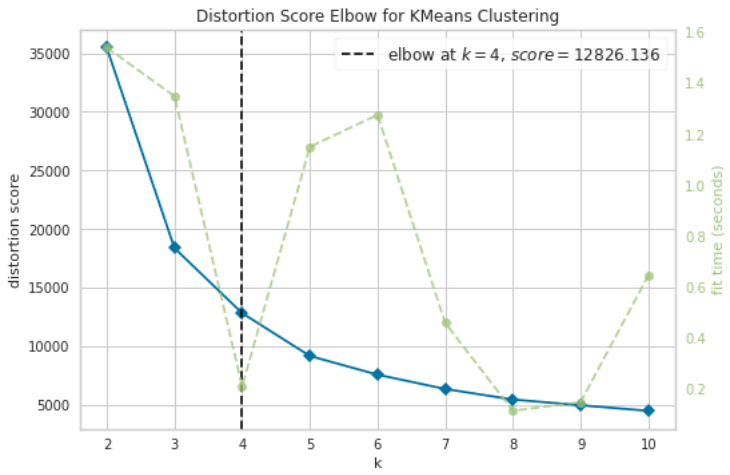
As initially thought, Education is not correlated with the total amount spent per purchase. Alternatively, the number of children is negatively correlated with the total amount spent per purchase. Initial thoughts were those with children would be more likely to shop at our store. This is not the case, it seems that those with children are not likely to spend at the store.

```
pca = PCA(n_components=4)
pca.fit(ds_sub)
PCA_df = pd.DataFrame(pca.transform(ds_sub), columns=(["Education","Income_tier", "Children", "Marital_Status"]))
PCA_df.describe().T
```

	count float64	mean float64	std float64	min float64	25% float64	50% float64	75% float64	max flo
Education	2216	-6.412840575452168e-17	7.803489689821501	-15.051465648292709	-7.129754691287002	0.3434822165332493	6.310719740523073	29.1513
Income_tier	2216	-2.885778258953475e-17	0.9720637960528299	-3.2502016163128102	-0.4588378829071756	0.16648743684790776	0.6334475311798855	4.10272
Children	2216	-7.855729704928905e-17	0.47976796424036616	-1.0003941675107537	-0.36934931180339414	-0.28240121132245627	0.5765913292737254	1.07968
Marital_Status	2216	1.4849733957531425e-16	0.456089090860484	-2.047716494763292	-0.2630501105319108	-0.014392363029189618	0.2979164839924324	2.42991

4 rows × 8 columns

```
model = KMeans()
visualizer = KElbowVisualizer(model, k=10)

visualizer.fit(PCA_df)
visualizer.show()
```




```
<AxesSubplot:title={'center':'Distortion Score Elbow for KMeans Clustering'}, xlabel='k', ylabel='distortic
```

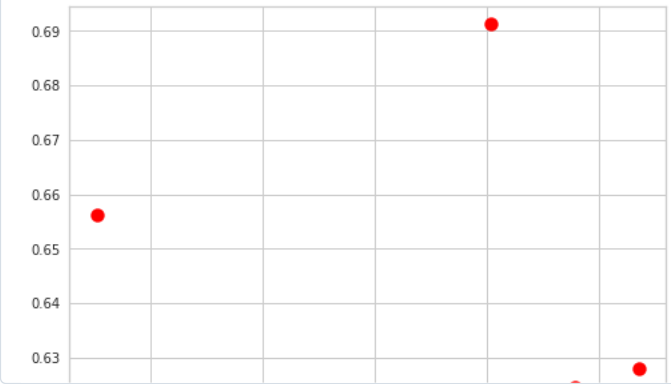
```
predictors = ds_sub
predictors = predictors.drop(columns = ['Total_tier'])

X = predictors
Y = df['Total_tier']
train_X, valid_X, train_Y, valid_Y = train_test_split(X,Y, test_size = .4, random_state = 1)
```

```
X
```

	Education float64 0.0 – 1.0	Marital_Status int64 0 – 1	Children int64 0 – 1	Income_tier int64 1 – 5	TotalNumPurchases int64 0 – 44
0	1	0	0	3	25
1	1	0	1	3	6
2	1	1	0	4	21
3	1	1	1	2	8
4	1	1	1	3	19
Expand rows 5 - 2210					
2235	1	1	1	3	18
2236	1	1	1	3	22
2237	1	0	0	3	19
2238	1	1	1	3	23
2239	1	1	1	3	11

2216 rows × 5 columns

```
kmeans = KMeans(n_clusters = 4, init = 'k-means++', max_iter = 300, n_init= 10, random_state = 0)
pred_y = kmeans.fit_predict(X)
#plt.scatter(X[:,0], c=Y, s=25, edgecolor='k')
plt.scatter(kmeans.cluster_centers_[:,0], kmeans.cluster_centers_[:,1], s=100, c='red')
plt.show()
```



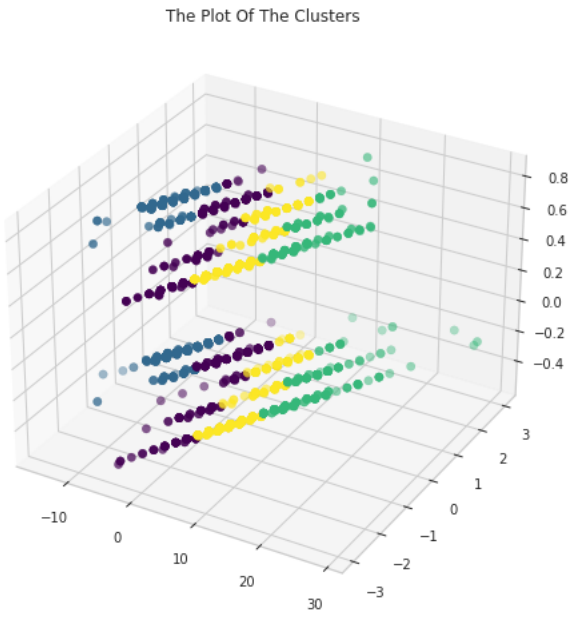

```
#Initiating the MiniBatchKMeans Clustering model
MP = MiniBatchKMeans(n_clusters=4)
# fit model and predict clusters
MP_df = MP.fit_predict(PCA_df)
PCA_df["Clusters"] = MP_df
#Adding the Clusters feature to the orignal dataframe.
df["Clusters"]= MP_df
```

```
/shared-libs/python3.7/py-core/lib/python3.7/site-packages/ipykernel_launcher.py:8: 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
```

```
ds_sub['Clusters'] = df['Clusters']
```

```
/shared-libs/python3.7/py-core/lib/python3.7/site-packages/ipykernel_launcher.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
  """Entry point for launching an IPython kernel.
```

```
#Plotting the clusters
fig = plt.figure(figsize=(10,8))
ax = plt.subplot(111, projection='3d', label="bla")
ax.scatter(x, y, z, s=40, c=PCA_df["Clusters"], marker='o', cmap = 'viridis' )
ax.set_title("The Plot Of The Clusters")
plt.show()
```




```
pl = sns.countplot(x=df["Clusters"])
```

```
pl.set_title("Distribution Of The Clusters")
plt.show()
```


```
sns.set(rc={'axes.facecolor':'black', 'figure.facecolor':'black', 'axes.grid' : False, 'font.family': 'Ubuntu'})

for i in ds_sub:
    diag = sns.FacetGrid(df, col = "Clusters", hue = "Clusters", palette = "Set1")
    diag.map(plt.hist, i, bins=6, ec="k")
    diag.set_xticklabels(rotation=25, color = 'white')
    diag.set_yticklabels(color = 'white')
    diag.set_xlabels(size=16, color = 'white')
    diag.set_titles(size=16, color = '#f01132', fontweight="bold")
    diag.fig.set_figheight(6)
```

```
findfont: Font family ['Ubuntu'] not found. Falling back to DejaVu Sans.
findfont: Font family ['Ubuntu'] not found. Falling back to DejaVu Sans.
findfont: Font family ['Ubuntu'] not found. Falling back to DejaVu Sans.
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findfont: Font family ['Ubuntu'] not found. Falling back to DejaVu Sans.
```
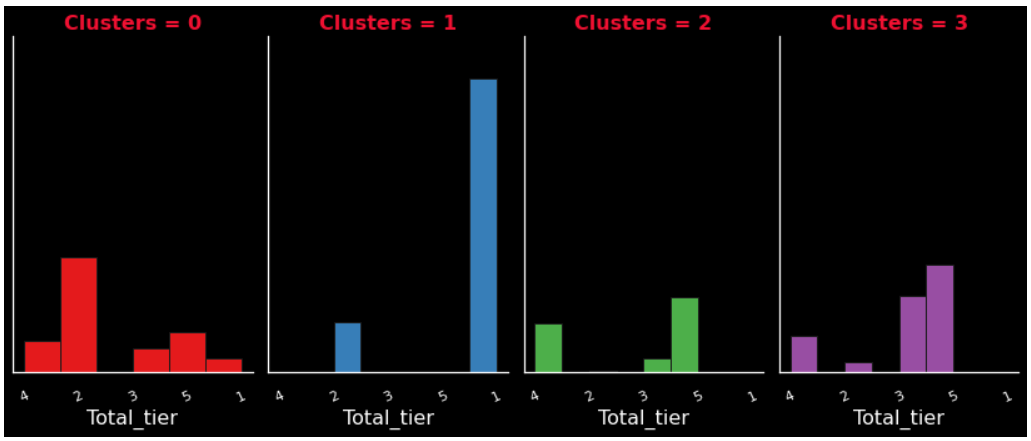
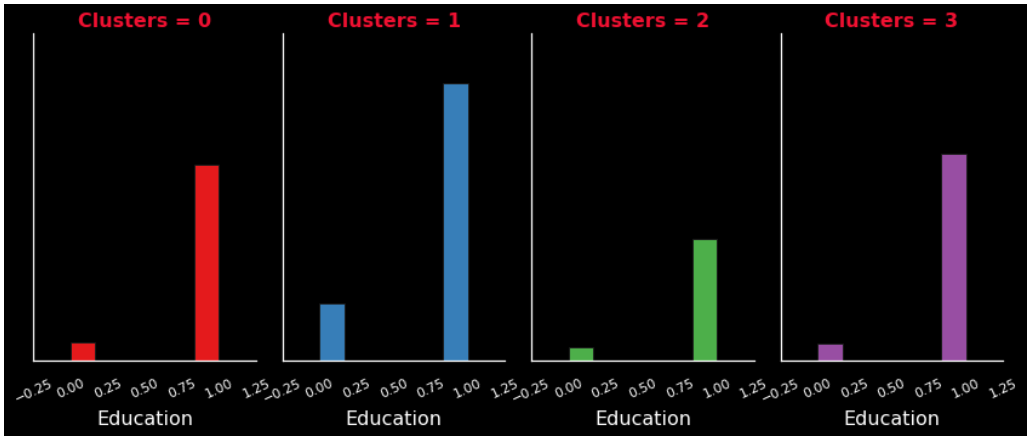
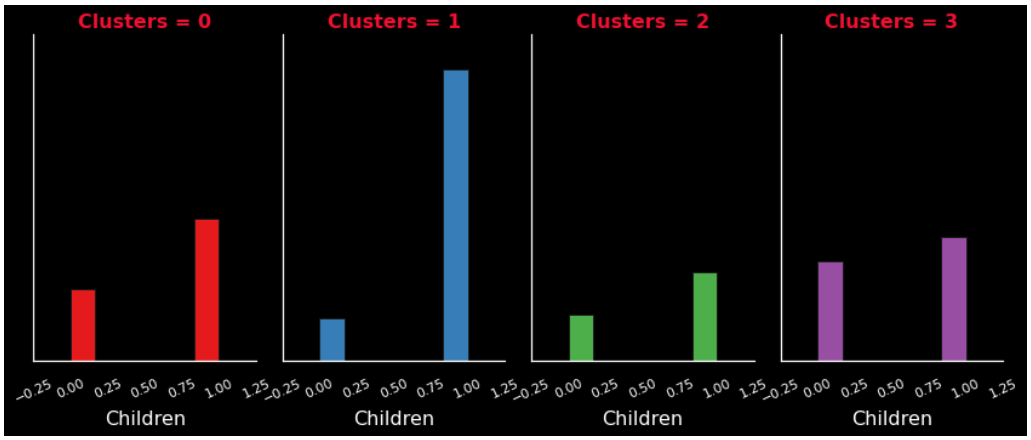
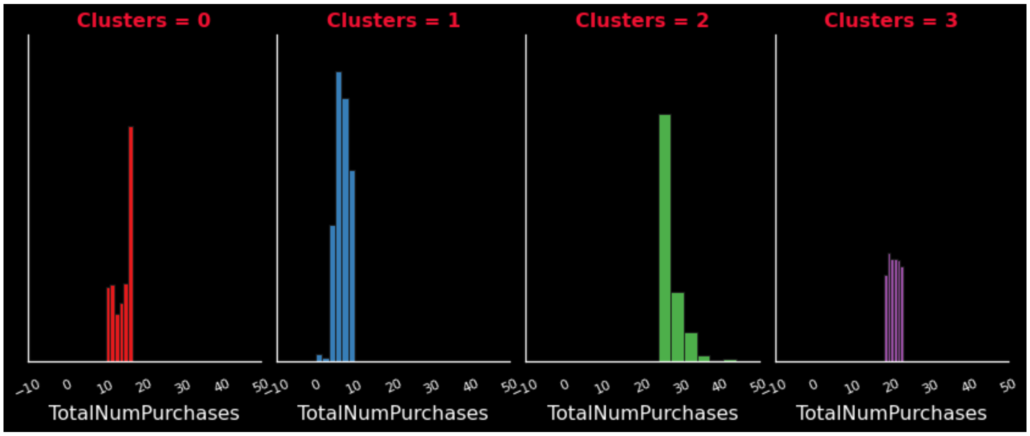



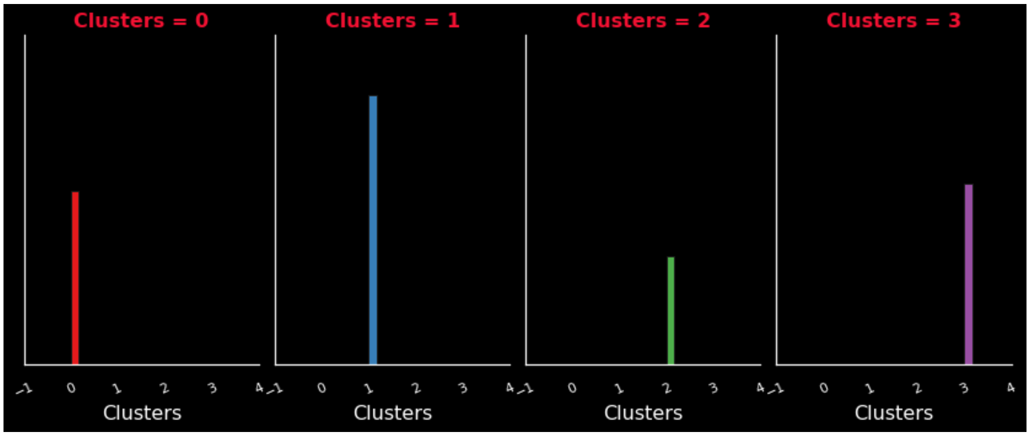

Clusters = 0
Clusters = 1
Clusters = 2
Clusters = 3
−0.25 0.00 0.25 0.50 0.75 1.00 1.25
Education


Clusters = 0
Clusters = 1
Clusters = 2
Clusters = 3
−0.25 0.00 0.25 0.50 0.75 1.00 1.25
Marital_Status


Clusters = 0
Clusters = 1
Clusters = 2
Clusters = 3
−0.25 0.00 0.25 0.50 0.75 1.00 1.25
Children


Clusters = 0
Clusters = 1
Clusters = 2
Clusters = 3
3 2 4 1 5
Income_tier






```python
# Model 1: Logistic Regression
logreg = LogisticRegressionCV(penalty = "l2", solver = 'saga', cv =5)
logreg.fit(train_X, train_Y)
classificationSummary(train_Y, logreg.predict(train_X))
classificationSummary(valid_Y, logreg.predict(valid_X))
```

```
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
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/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
```

```
ds_sub.head()
```

	Total_tier int64	Education float64	Marital_Status int64	Children int64	Income_tier int64	TotalNumPurchases int64	Clusters int32
0	5	1	0	0	3	25	2
1	1	1	0	1	3	6	1
2	3	1	1	0	4	21	3
3	1	1	1	1	2	8	1
4	2	1	1	1	3	19	3

5 rows × 7 columns

```
#kmeans
points = ds_sub
kmeans3 = cluster.KMeans(n_clusters=4, random_state=0).fit(points)
ds_sub['cluster'] = kmeans3.labels_

centroids = kmeans3.cluster_centers_
dists = pd.DataFrame(    sdist.cdist(points, centroids),
    columns=['dist_{}'.format(i) for i in range(len(centroids))],
    index=ds_sub.index)
df_km = pd.concat([ds_sub, dists], axis=1)
print(df_km)
```

```
2238          4       1.0              1        1           3
2239          2       1.0              1        1           3

      TotalNumPurchases  Clusters  cluster     dist_0     dist_1     dist_2  \
0                    25         2        1  11.038897   2.211104  18.892144
1                     6         1        2   8.958940  21.213686   1.197180
2                    21         3        3   7.907972   6.510330  14.817441
3                     8         1        2   7.160191  19.287515   1.477476
4                    19         3        3   6.302954   8.556825  12.650164
...                 ...       ...      ...        ...        ...        ...
2235                 18         3        3   5.959285   9.185266  12.262584
2236                 22         3        3   8.680580   5.580848  15.687183
2237                 19         3        3   6.648558   8.265047  13.236776
2238                 23         3        3   9.631185   4.532822  16.810145
2239                 11         0        0   3.585433  16.220829   5.074274

         dist_3
0      5.185112
1     15.028085
2      1.455814
3     13.166929
4      2.651725
...         ...
2235   2.785543
2236   1.955777
2237   2.023314
2238   2.586107
2239  10.644695

[2216 rows x 12 columns]
/shared-libs/python3.7/py-core/lib/python3.7/site-packages/ipykernel_launcher.py:9: SettingWithCopyWarning:
```

```
# Model 1: Logistic Regression
logreg = LogisticRegressionCV(penalty = "l2", solver = 'saga', cv =5)
logreg.fit(train_X, train_Y)

logpred = logreg.predict(valid_X)
classificationSummary(train_Y, logreg.predict(train_X))
classificationSummary(valid_Y, logreg.predict(valid_X))
```

```
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
```

```
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
  ConvergenceWarning,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_sag.py:354: ConvergenceWarning: The max_iter was reached which means the coef_ did not converge
```

```python
# Model 2: Naive Bayes
nb = GaussianNB()
nb.fit(train_X, train_Y)

nbpred = nb.predict(valid_X)
classificationSummary(train_Y, nb.predict(train_X))
classificationSummary(valid_Y, nb.predict(valid_X))
```

```
Confusion Matrix (Accuracy 0.7291)

       Prediction
Actual   0   1   2   3   4
     0 400  22   0   0   0
     1  52 171  23   2   7
     2   0  21 124   7  24
     3   0   8  53  30  75
     4   0   2  31  33 244
Confusion Matrix (Accuracy 0.7249)

       Prediction
Actual   0   1   2   3   4
     0 293  13   0   0   4
     1  28 110  19   1   3
     2   0  11  60   4  17
     3   0   9  39  18  42
     4   0   1  21  32 162
```

```python
# Model 3: SVM
clf = svm.SVC(kernel='linear')
clf.fit(train_X, train_Y)
y_pred1 = clf.predict(valid_X)
classificationSummary(train_Y, clf.predict(train_X))
classificationSummary(valid_Y, clf.predict(valid_X))
```

```
Confusion Matrix (Accuracy 0.7299)

       Prediction
Actual   0   1   2   3   4
     0 399  23   0   0   0
     1  49 184  18   3   1
     2   0  25 121  14  16
     3   0  16  43  46  61
     4   0   6  26  58 220
Confusion Matrix (Accuracy 0.7159)

       Prediction
Actual   0   1   2   3   4
     0 293  16   0   0   1
     1  26 113  19   1   2
```

```
 2   0  10  53  14  15
 3   0  14  30  33  31
 4   0   7  22  44 143
```

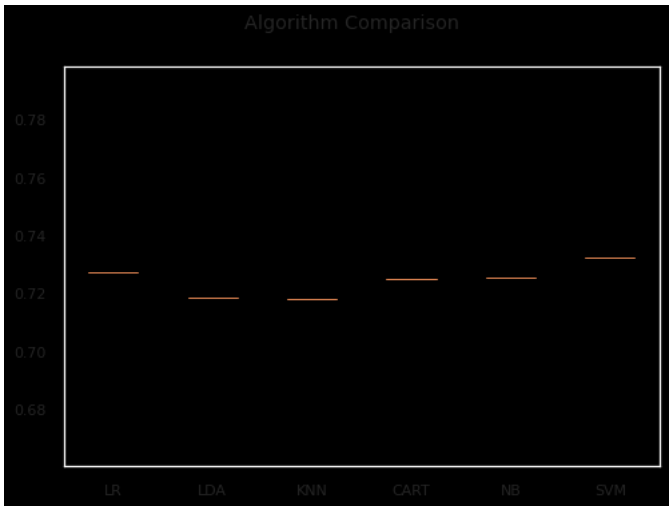
```python
# prepare models
models = []
models.append(('LR', LogisticRegression()))
models.append(('LDA', LinearDiscriminantAnalysis()))
models.append(('KNN', KNeighborsClassifier()))
models.append(('CART', DecisionTreeClassifier()))
models.append(('NB', GaussianNB()))
models.append(('SVM', SVC()))
#Set Seed
seed = 7
# evaluate each model in turn
results = []
names = []
scoring = 'accuracy'
for name, model in models:
        kfold = model_selection.KFold(n_splits=10)
        cv_results = model_selection.cross_val_score(model, X, Y, cv=kfold, scoring=scoring)
        results.append(cv_results)
        names.append(name)
        msg = "%s: %f (%f)" % (name, cv_results.mean(), cv_results.std())
        print(msg)
# boxplot algorithm comparison
fig = plt.figure()
fig.suptitle('Algorithm Comparison')
ax = fig.add_subplot(111)
plt.boxplot(results)
ax.set_xticklabels(names)
plt.show()
```

```
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_logistic.py:818: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_logistic.py:818: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG,
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/linear_model/_logistic.py:818: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG,
LR: 0.718426 (0.031639)
LDA: 0.727439 (0.032619)
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/base.py:442: UserWarning: X does not have valid feature names, but KNeighborsClassifier was fitted with feature names
  "X does not have valid feature names, but"
/shared-libs/python3.7/py/lib/python3.7/site-packages/sklearn/base.py:442: UserWarning: X does not have valid feature names, but KNeighborsClassifier was fitted with feature names
  "X does not have valid feature names, but"
```



Out of the 7 models we've run (Logistic Regression, LDA, K-Nearest Neighbors, CART, Naive Bayes, and SVM), all achieved roughly the same accuracy, our metric for performance.

With that being said, the Naive Bayes algorithm achieved an accuracy of 73.1% followed closely by SVM at 73.0%.

The results of our model indicates which demographic should be targetted with respect to education levels, parenthood, income, marital status, and spending habits to increase sales.