In [2]:

```
%matplotlib inline
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import scipy.stats
import os
from IPython.core.interactiveshell import InteractiveShell
import lifelines as ll
InteractiveShell.ast_node_interactivity = "all"
```

In [3]:

```
pd.set_option('display.max_columns', None)
```

In [4]:

```
df = pd.read_csv('WA_Fn-UseC_-Telco-Customer-Churn.csv')
```

In [5]:

```
df
```

Out[5]:

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleL
0	7590-VHVEG	Female	0	Yes	No	1	No	No pl se
1	5575-GNVDE	Male	0	No	No	34	Yes	
2	3668-QPYBK	Male	0	No	No	2	Yes	
3	7795-CFOCW	Male	0	No	No	45	No	No pl se
4	9237-HQITU	Female	0	No	No	2	Yes	
5	9305-CDSKC	Female	0	No	No	8	Yes	
6	1452-KIOVK	Male	0	No	Yes	22	Yes	

In [6]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 21 columns):
customerID          7043 non-null object
gender              7043 non-null object
SeniorCitizen       7043 non-null int64
Partner             7043 non-null object
Dependents          7043 non-null object
tenure              7043 non-null int64
PhoneService        7043 non-null object
MultipleLines       7043 non-null object
InternetService     7043 non-null object
OnlineSecurity      7043 non-null object
OnlineBackup        7043 non-null object
DeviceProtection    7043 non-null object
TechSupport         7043 non-null object
StreamingTV         7043 non-null object
StreamingMovies     7043 non-null object
Contract            7043 non-null object
PaperlessBilling    7043 non-null object
PaymentMethod       7043 non-null object
MonthlyCharges      7043 non-null float64
TotalCharges        7043 non-null object
Churn               7043 non-null object
dtypes: float64(1), int64(2), object(18)
memory usage: 1.1+ MB
```

In [7]:

```
df = pd.get_dummies(data=df, columns=['gender'])
df['Partner'] = df['Partner'].map(lambda s :1  if s =='Yes' else 0)
df['Dependents'] = df['Dependents'].map(lambda s :1  if s =='Yes' else 0)
df['PhoneService'] = df['PhoneService'].map(lambda s :1  if s =='Yes' else 0)
df['PaperlessBilling'] = df['PaperlessBilling'].map(lambda s :1  if s =='Yes' els
df = pd.get_dummies(data=df, columns=['MultipleLines'])
df = pd.get_dummies(data=df, columns=['InternetService'])
df['OnlineSecurity'] = df['OnlineSecurity'].map(lambda s :1  if s =='Yes' else 0
df['OnlineBackup'] = df['OnlineBackup'].map(lambda s :1  if s =='Yes' else 0)
df['DeviceProtection'] = df['DeviceProtection'].map(lambda s :1  if s =='Yes' els
df['TechSupport'] = df['TechSupport'].map(lambda s :1  if s =='Yes' else 0)
df['StreamingTV'] = df['StreamingTV'].map(lambda s :1  if s =='Yes' else 0)
df['StreamingMovies'] = df['StreamingMovies'].map(lambda s :1  if s =='Yes' else
df = pd.get_dummies(data=df, columns=['PaymentMethod'])
df = pd.get_dummies(data=df, columns=['Contract'])
```

In [8]:

```
df = df[df['TotalCharges'] != " "]
df['TotalCharges'] = df['TotalCharges'].astype('float64')
```

In [9]:
```
df
```

Out[9]:

	customerID	SeniorCitizen	Partner	Dependents	tenure	PhoneService	OnlineSecurity	O
0	7590-VHVEG	0	1	0	1	0	0	
1	5575-GNVDE	0	0	0	34	1	1	
2	3668-QPYBK	0	0	0	2	1	1	
3	7795-CFOCW	0	0	0	45	0	1	
4	9237-HQITU	0	0	0	2	1	0	
5	9305-CDSKC	0	0	0	8	1	0	
6	1452-	0	0	1	22	1	0	

In [10]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 7032 entries, 0 to 7042
Data columns (total 31 columns):
customerID                                 7032 non-null object
SeniorCitizen                              7032 non-null int64
Partner                                    7032 non-null int64
Dependents                                 7032 non-null int64
tenure                                     7032 non-null int64
PhoneService                               7032 non-null int64
OnlineSecurity                             7032 non-null int64
OnlineBackup                               7032 non-null int64
DeviceProtection                           7032 non-null int64
TechSupport                                7032 non-null int64
StreamingTV                                7032 non-null int64
StreamingMovies                            7032 non-null int64
PaperlessBilling                           7032 non-null int64
MonthlyCharges                             7032 non-null float64
TotalCharges                               7032 non-null float64
Churn                                      7032 non-null object
gender_Female                              7032 non-null uint8
gender_Male                                7032 non-null uint8
MultipleLines_No                           7032 non-null uint8
MultipleLines_No phone service             7032 non-null uint8
MultipleLines_Yes                          7032 non-null uint8
InternetService_DSL                        7032 non-null uint8
InternetService_Fiber optic                7032 non-null uint8
InternetService_No                         7032 non-null uint8
PaymentMethod_Bank transfer (automatic)    7032 non-null uint8
PaymentMethod_Credit card (automatic)      7032 non-null uint8
PaymentMethod_Electronic check             7032 non-null uint8
PaymentMethod_Mailed check                 7032 non-null uint8
Contract_Month-to-month                    7032 non-null uint8
Contract_One year                          7032 non-null uint8
Contract_Two year                          7032 non-null uint8
dtypes: float64(2), int64(12), object(2), uint8(15)
memory usage: 1.0+ MB
```

In [11]:
```
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import RandomForestRegressor
from sklearn.neural_network import MLPClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.cluster import KMeans
from sklearn.cluster import DBSCAN
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.metrics import mean_squared_error
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import RandomizedSearchCV
from sklearn.model_selection import GridSearchCV
```

In [12]:
```
class Data:
    def __init__(self, columns, label, df = df, seed=42):
        data = df[columns + label].dropna()
        X = data[columns]
        y = data[label[0]]

        x_train, x_test, y_train, y_test = train_test_split(X, y, test_size=0.3,

        self.X, self.y = x_train, y_train
        self.vX, self.vy = x_test, y_test

    def train(self):
        return self.X, self.y

    def valid(self):
        return self.vX, self.vy
```

In [13]:
```
def tuning(estimator, X, label, grid, one_by_one=False):

    data=Data(X, label)

    if one_by_one:
        extra_cl_random = GridSearchCV(estimator=estimator, param_grid=grid)

    else:
        extra_cl_random = RandomizedSearchCV(estimator=estimator, param_distribut

    extra_cl_random.fit(*data.train())

    best = extra_cl_random.best_estimator_
    tscore = best.score(*data.train())
    vscore = best.score(*data.valid())
    params = best.get_params()

    print('vscore:', vscore)
    print('best_params:', params)
```

In [14]:
```
label = ['Churn']
columns = ['SeniorCitizen', 'Partner', 'Dependents', 'tenure', 'PhoneService',
           'OnlineSecurity', 'OnlineBackup', 'DeviceProtection', 'TechSupport', '
          'PaperlessBilling', 'MonthlyCharges', 'TotalCharges','gender_Female','g
          'MultipleLines_No phone service', 'MultipleLines_Yes', 'InternetService
          'InternetService_No', 'PaymentMethod_Bank transfer (automatic)', 'Payme
          'PaymentMethod_Electronic check', 'PaymentMethod_Mailed check', 'Contra
          'Contract_Two year']
```

In [15]:
```
def knn(X, labels,**knn_params):
    data = Data(X,labels)
    neigh = KNeighborsClassifier(**knn_params)
    neigh.fit(*data.train())
    score_train = neigh.score(*data.train())
    score = neigh.score(*data.valid())

    print('accuracy:', (score_train, score))

    return neigh, data, score_train, score
```

In [16]:
```
def xgboost(columns, label, **xg_params):

    data = Data(columns, label)
    xgb = GradientBoostingClassifier(**xg_params)
    xgb.fit(*data.train())
    vscore = xgb.score(*data.valid())

    #mse = mean_squared_error(*data.valid())

    return vscore
```

Random Forest Classifier

In [17]:
```
def rfc(columns, labels, **rfc_params):

    data = Data(columns, labels)

    rfc = RandomForestClassifier(**rfc_params)
    rfc.fit(*data.train())

    tscore = rfc.score(*data.train())
    vscore = rfc.score(*data.valid())

    print("final tscore=%g vscore=%g" % (tscore, vscore))

    return rfc, data, tscore, vscore
```

In [17]:
```
rfc_, data, tscore, vscore = rfc(columns, label, n_estimators=100, criterion='gi
                                     min_samples_split=5, min_samples_leaf=1, mi
                                     max_features='auto', max_leaf_nodes=None, b
                                     n_jobs=1, random_state=42)
```

```
final tscore=0.956522 vscore=0.790995
```

In [18]:

```
y_true = np.ravel(data.vy)
y_pred = np.ravel(rfc_.predict(data.vX))
pd.DataFrame(confusion_matrix(y_true, y_pred))
```

Out[18]:

	0	1
0	1386	163
1	278	283

In [19]:

```
n_estimators = [int(x) for x in np.linspace(start = 10, stop = 200, num = 10)]
max_features = ['auto', 'sqrt', 'log2', None]
max_depth = [int(x) for x in np.linspace(10, 300, num = 10)]
max_depth.append(None)
min_samples_split = [2, 5, 10]
min_samples_leaf = [1, 2, 4]
bootstrap = [True, False]
criterion = ['gini', 'entropy']
random_state = [100]

random_grid = {'n_estimators': n_estimators,
               'max_features': max_features,
               'max_depth': max_depth,
               'min_samples_split': min_samples_split,
               'min_samples_leaf': min_samples_leaf,
               'bootstrap': bootstrap,
               'criterion': criterion,
               'random_state': random_state}
```

In [ ]:

```
tuning(RandomForestClassifier(), columns, label, random_grid)
```

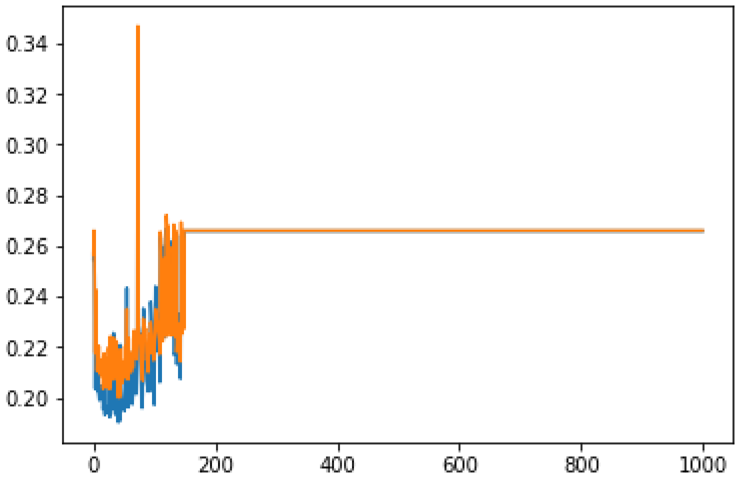
MLP

In [25]:
```
def mlpc(columns, labels, **mlp_params):

    data = Data(columns, labels)

    mlperc = MLPClassifier(**mlp_params)
    max_iter = mlp_params.pop('max_iter')

    tscores = []
    vscores = []

    for epoch in range(max_iter):

        mlperc.set_params(max_iter=epoch+1)
        mlperc.fit(*data.train())

        tscore = mlperc.score(*data.train())
        vscore = mlperc.score(*data.valid())

        loss = mlperc.loss_
        tscores.append(tscore)
        vscores.append(vscore)

        mlperc.set_params(warm_start=True)

    print("final tscore=%g vscore=%g" % (tscore, vscore))

    return mlperc, data, tscores, vscores
```

In [26]:
```
mlp, data, tscores, vscores = mlpc(columns, label, max_iter=1000, hidden_layer_si
                                       batch_size = 110, learning_rate_init=1e-1,
                                       learning_rate = 'constant', momentum = 0.0
                                       verbose = False, alpha=0.0, tol = -1)
```

```
C:\Users\giamm\Anaconda3\lib\site-packages\sklearn\neural_network\multilayer_pe
rceptron.py:564: ConvergenceWarning: Stochastic Optimizer: Maximum iterations
(1) reached and the optimization hasn't converged yet.
  % self.max_iter, ConvergenceWarning)

final tscore=0.734254 vscore=0.734123
```

In [27]:
```
plt.plot(range(len(tscores)), 1-np.array(tscores), range(len(vscores)), 1-np.arra
```



KNN

In [22]:
```
neigh, data, score_train, score = knn(columns, label, weights='distance')
```

```
accuracy: (0.9985778138967899, 0.7635071090047393)
```

In [23]:
```
y_true = np.ravel(data.vy)
y_pred = np.ravel(neigh.predict(data.vX))
pd.DataFrame(confusion_matrix(y_true, y_pred))
```

Out[23]:

	0	1
0	1354	195
1	304	257

XGB

In [37]:
```
xgboost(columns, label, random_state=42)
```

Out[37]:
```
0.7976303317535545
```

Survival Analysis

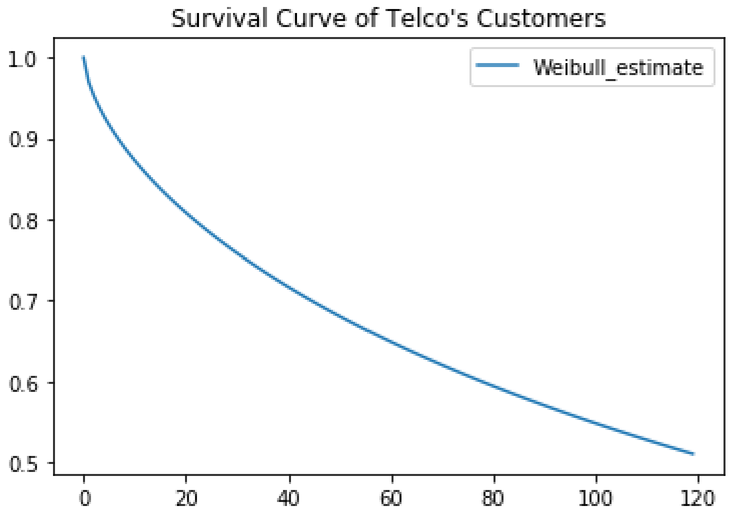
In [25]:
```
df = df[df.tenure != 0]
df['Churn'] = df['Churn'].map(lambda s :1  if s =='Yes' else 0)
```

In [40]:
```
def plot_surv_weibull(weibull_model, ax, max_time = 120):
    max_time = np.floor(max_time).astype(int)
    x = np.array(range(max_time))
    y = np.exp(-(weibull_model.lambda_*x)**weibull_model.rho_)
    ax.plot(x,y, label = weibull_model._label)
    plt.legend()
```

In [41]:
```
weib = ll.WeibullFitter()
weib.fit(durations = df.tenure, event_observed = df.Churn)
ax = plt.subplot(111)
plot_surv_weibull(weib, ax)
plt.title("Survival Curve of Telco's Customers")
```

Out[41]:
```
<lifelines.WeibullFitter: fitted with 7032 observations, 5163 censored>
```

Out[41]:
```
Text(0.5,1,"Survival Curve of Telco's Customers")
```



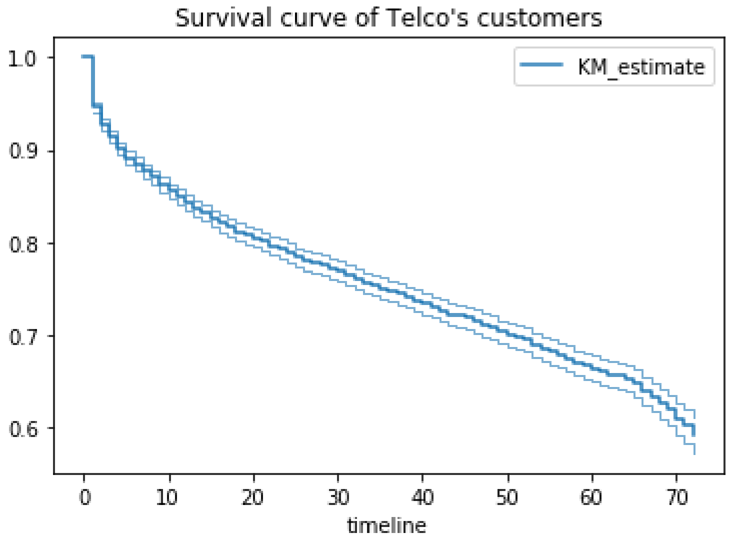
In [31]:
```
from lifelines import KaplanMeierFitter
```

In [37]:
```
#Survival curve (Keplen Meier model) with confidence intervals (Greenwood exponer
ax = plt.subplot(111)
kmf = KaplanMeierFitter()
kmf.fit(durations = df.tenure, event_observed = df.Churn)
kmf.plot(ax=ax, ci_force_lines=True)
plt.title("Survival curve of Telco's customers")
```

Out[37]:
```
<lifelines.KaplanMeierFitter: fitted with 7032 observations, 5163 censored>
```

Out[37]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1bc64f7d400>
```

Out[37]:
```
Text(0.5,1,"Survival curve of Telco's customers")
```



Comparison between variables (segmentation)

In [59]:

```
axes = plt.subplot(111)
kmf_male = ll.KaplanMeierFitter()
kmf_female = ll.KaplanMeierFitter()

is_male = (df['gender_Male'] == 1)
kmf_male.fit(durations = df.tenure[is_male], event_observed = df.Churn[is_male],
#kmf_male.plot(ax=axes[0][0], ci_force_lines=False)
kmf_male.survival_function_.plot(ax = axes)
kmf_female.fit(durations = df.tenure[~is_male], event_observed = df.Churn[~is_mal
#kmf_female.plot(ax=axes[0][0], ci_force_lines=False)
kmf_female.survival_function_.plot(ax = axes)

plt.title("Male vs Female Survival Curve")
```

Out[59]:

```
<lifelines.KaplanMeierFitter: fitted with 3549 observations, 2619 censored>
```

Out[59]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1bc66d0abe0>
```

Out[59]:

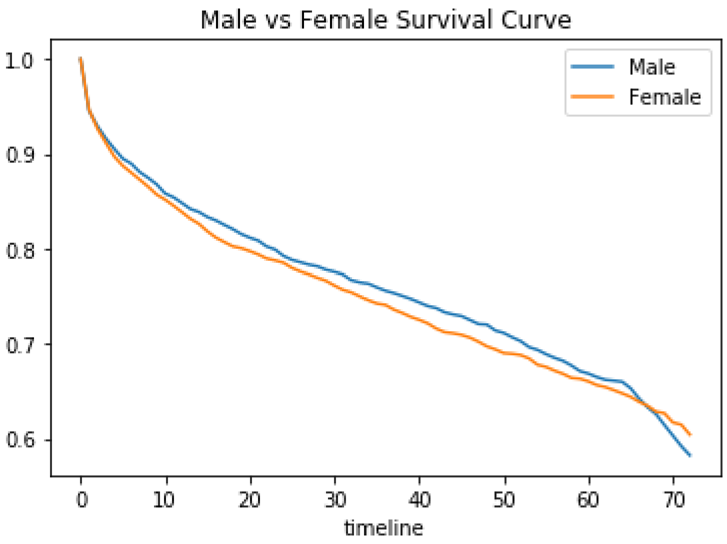
```
<lifelines.KaplanMeierFitter: fitted with 3483 observations, 2544 censored>
```

Out[59]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1bc66d0abe0>
```

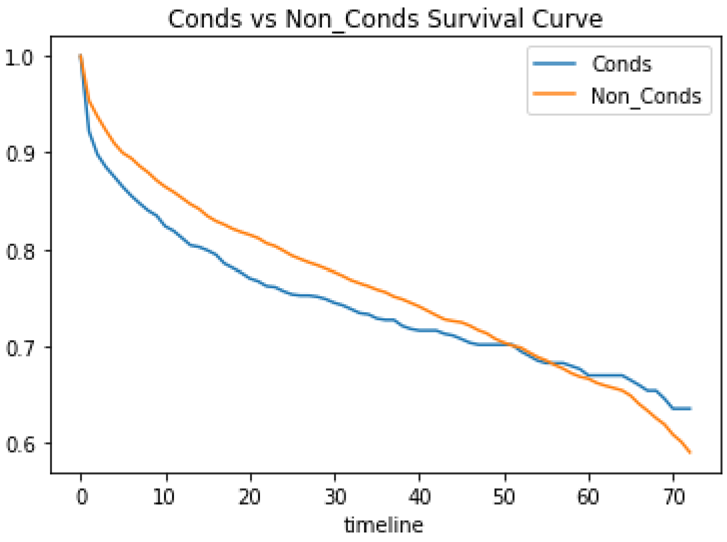
Out[59]:

```
Text(0.5,1,'Male vs Female Survival Curve')
```



```
In [69]: #Testing multiple conditions (segmentation)
         is_male = ((df['gender_Male'] == 1) & (df['MultipleLines_No'] == 1))
         axes = plt.subplot(111)
         kmf_conds = ll.KaplanMeierFitter()
         kmf_non_conds = ll.KaplanMeierFitter()

         conds = ((df['gender_Male'] == 1) & (df['MultipleLines_No'] == 1))
         kmf_conds.fit(durations = df.tenure[conds], event_observed = df.Churn[conds], lab
         kmf_conds.survival_function_.plot(ax = axes)
         kmf_non_conds.fit(durations = df.tenure[~conds], event_observed = df.Churn[~conds
         kmf_non_conds.survival_function_.plot(ax = axes)

         plt.title("Conds vs Non_Conds Survival Curve")
```

```
Out[69]: <lifelines.KaplanMeierFitter: fitted with 1716 observations, 1310 censored>

Out[69]: <matplotlib.axes._subplots.AxesSubplot at 0x1bc65405240>

Out[69]: <lifelines.KaplanMeierFitter: fitted with 5316 observations, 3853 censored>

Out[69]: <matplotlib.axes._subplots.AxesSubplot at 0x1bc65405240>

Out[69]: Text(0.5,1,'Conds vs Non_Conds Survival Curve')
```



```
In [ ]:
```