In [1359]:
```
# tag_id is converted to dummy variable to use in regression models
tag_id = pd.get_dummies(device_df['tag_id'])
print(tag_id.head())
```

```
    0   3   4   5   8   10
4    1   0   0   0   0   0
6    1   0   0   0   0   0
9    1   0   0   0   0   0
11   1   0   0   0   0   0
12   1   0   0   0   0   0
```

In [1360]:
```
 variables for user 495, 496, and users assigned
5_df = pd.read_csv('data_495.csv')
6_df = pd.read_csv('data_496.csv')
4_df = pd.read_csv('data_524.csv')
2_df = pd.read_csv('data_582.csv')
4_df = pd.read_csv('data_664.csv')
5_df = pd.get_dummies(data495_df, columns =['tag_0','tag_1','tag_2','tag_3','tag_4'
6_df = pd.get_dummies(data496_df, columns =['tag_0','tag_1','tag_2','tag_3','tag_4'
4_df = pd.get_dummies(data524_df, columns =['tag_0','tag_1','tag_2','tag_3','tag_4'
2_df = pd.get_dummies(data582_df, columns =['tag_0','tag_1','tag_2','tag_3','tag_4'
4_df = pd.get_dummies(data664_df, columns =['tag_0','tag_1','tag_2','tag_3','tag_4'
y(data524_df)
```

	Unnamed: 0	client_time	step	battery_low	is_charge	tag_battery_low	tag_0_0	tag_0_1	tag_1_0	tag_1_
0	14052	2020-08-04 14:03:46	1069	29	0	0	1	0	1	
1	14053	2020-08-04 14:07:54	1107	31	0	0	1	0	1	
2	14054	2020-08-04 14:10:11	1114	30	0	0	1	0	1	
3	14055	2020-08-04 14:12:03	1122	29	0	0	1	0	1	
4	14056	2020-08-04 14:12:31	1133	29	0	0	1	0	1	
...	...	...	...	...	...	...	...	...	...	...
9477	160002	2020-11-02 10:31:57	867	21	0	0	0	1	1	
9478	160007	2020-11-02 10:38:00	919	22	0	0	1	0	1	
9479	160008	2020-11-02 10:38:25	927	21	0	0	1	0	1	
9480	160009	2020-11-02 10:39:28	955	21	0	0	1	0	1	
9481	160011	2020-11-02 10:40:08	966	22	0	0	0	1	1	

9482 rows × 27 columns

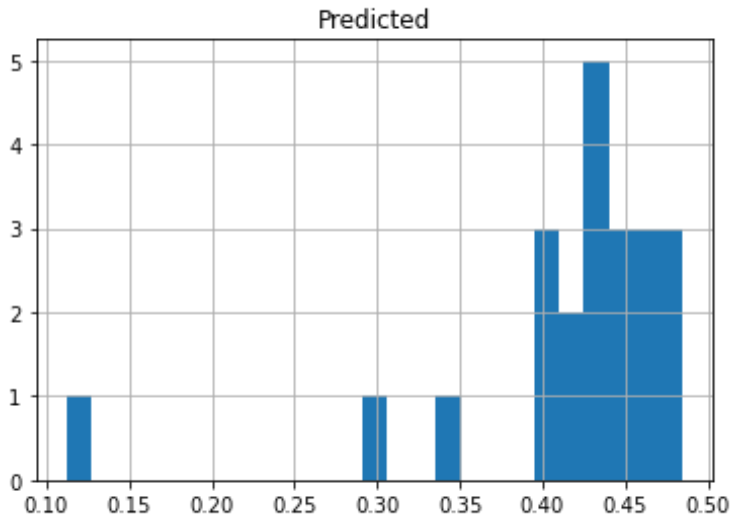
In [1361]:
```
#multiple linear regression model to depression score using tag id, step, and batte
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression, Lasso, Ridge, LassoCV, BayesianR
import statsmodels.formula.api as sm
import matplotlib.pylab as plt
from dmba import regressionSummary, exhaustive_search
from dmba import backward_elimination, forward_selection, stepwise_selection
from dmba import adjusted_r2_score, AIC_score, BIC_score
device_df = device_df.iloc[0:53] #53 samples due to shape of user1 df

#predictors and outcome
predictors = ['tag_id', 'step', 'battery_low']
outcome = 'depression_score'

# partition data 60% training 40% validation
X = pd.get_dummies(device_df[predictors], drop_first=True)
y = user1_df[outcome]
train_X, valid_X, train_y, valid_y = train_test_split(X, y, test_size=0.4, random_s

depression_lm = LinearRegression()
depression_lm.fit(train_X, train_y)

# print coefficients
print(pd.DataFrame({'Predictor': X.columns, 'coefficient': depression_lm.coef_}))

# print performance measures (training data)
regressionSummary(train_y, depression_lm.predict(train_X))
depression_lm_pred = depression_lm.predict(valid_X)

result = pd.DataFrame({'Predicted': depression_lm_pred, 'Actual': valid_y,'Residual
print(result.head(20))

#Equation
# Y denoted as depression score
# Y =  0.4278355158048195 + (-0.037461*tag_id) +  (-0.000005*step) + (0.000627*batt
print(depression_lm.intercept_) #for equation(b0- meaning value when all is equal t
print(depression_lm.coef_)
#positive coefficient from battery_low shows that as the "value of the independent
#the mean of the dependent variable also increases"
```

```
     Predictor  coefficient
0       tag_id    -0.037461
1         step    -0.000005
2  battery_low     0.000627

Regression statistics

               Mean Error (ME) : 0.0000
Root Mean Squared Error (RMSE) : 0.2940
     Mean Absolute Error (MAE) : 0.2421
    Predicted  Actual  Residual
30   0.479116   0.625  0.145884
2    0.404174   0.125 -0.279174
51   0.404110   0.000 -0.404110
32   0.467960   0.125 -0.342960
31   0.470356   0.000 -0.470356
46   0.417404   0.000 -0.417404
34   0.463685   0.625  0.161315
39   0.444639   0.375 -0.069639
```

```
45    0.421871    0.250 -0.171871
19    0.112076    0.500  0.387924
10    0.445737    0.000 -0.445737
3     0.432602    0.250 -0.182602
21    0.335982    0.000 -0.335982
49    0.405671    0.000 -0.405671
38    0.449919    0.000 -0.449919
41    0.437635    0.125 -0.312635
24    0.484659    0.500  0.015341
42    0.436481    0.875  0.438519
40    0.439253    0.000 -0.439253
35    0.461401    0.500  0.038599
0.4278355158048195
[-3.74608102e-02 -5.39172374e-06  6.26904658e-04]
```

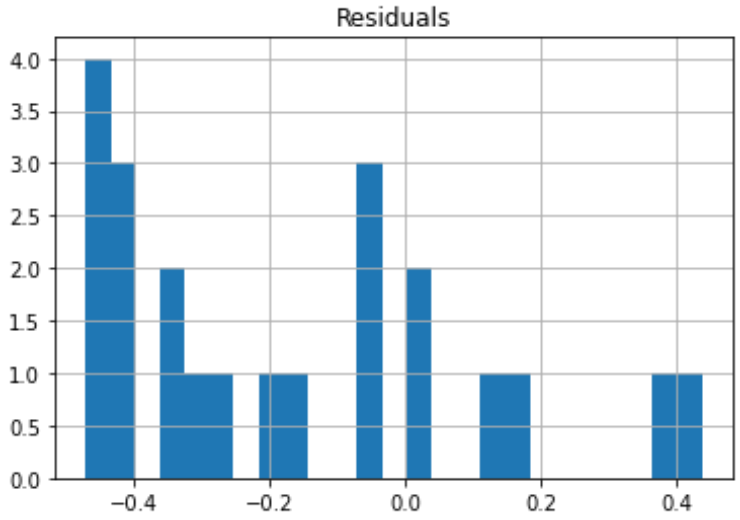
In [1362]:
```
all_predicted = depression_lm_pred
# Determine the percentage of datapoints with predicted values [.4, .5] = approx.
# 75%
# The percentage of datapoints with a predicted value in [.4, .5] = 75%
print(len(all_predicted[(all_predicted > .4) & (all_predicted < .5)]) / len(all_pre
pd.DataFrame({'Predicted': all_predicted}).hist(bins=25)
plt.show()
```

```
0.8636363636363636

/var/folders/db/g89vnvfj68l9dp9q6zz747zh0000gn/T/ipykernel_3731/2929344346.py:7:
UserWarning: Matplotlib is currently using agg, which is a non-GUI backend, so ca
nnot show the figure.
  plt.show()
```



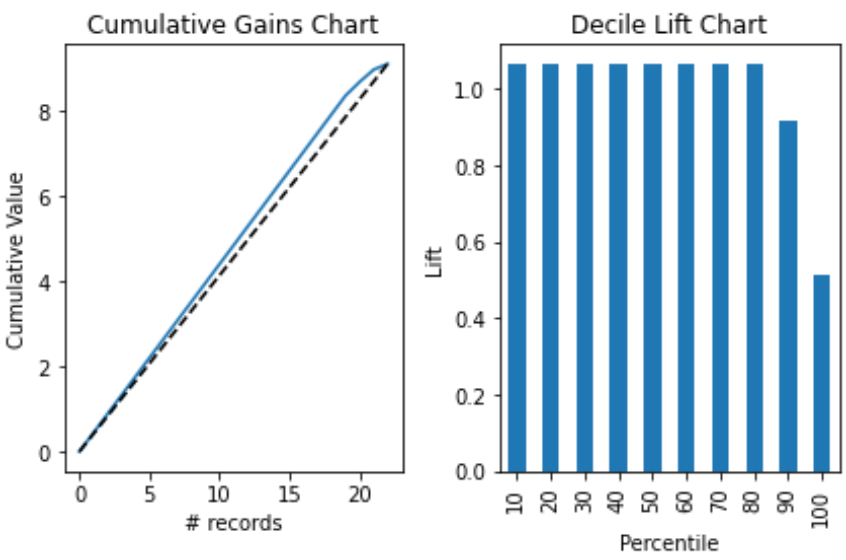
In [1363]:
```
all_residuals = valid_y - depression_lm_pred
# Determine the percentage of datapoints with a residual in [-.8, 1] = approx.
# 75%
# The percentage of datapoints with a residual in [-.8, 1] = 75%
print(len(all_residuals[(all_residuals > -.8) & (all_residuals < -1)]) / len(all_re
pd.DataFrame({'Residuals': all_residuals}).hist(bins=25)
plt.show()
```

```
0.0

/var/folders/db/g89vnvfj68l9dp9q6zz747zh0000gn/T/ipykernel_3731/43860018.py:7: Us
erWarning: Matplotlib is currently using agg, which is a non-GUI backend, so cann
ot show the figure.
  plt.show()
```



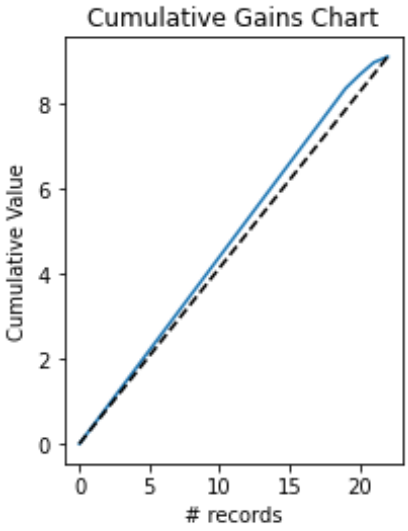
In [1364]:
```
# Forward Regression (Part C)
from dmba import forward_selection
from sklearn.linear_model import LinearRegression
from sklearn.metrics import accuracy_score, roc_curve, auc
import matplotlib.pylab as plt
from dmba import regressionSummary, classificationSummary
from dmba import liftChart, gainsChart
import math
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
def train_model(variables):
    if len(variables) == 0:
         return None
    model = LinearRegression()
    model.fit(train_X[variables], train_y)
    return model
def score_model(model, variables):
     if len(variables) == 0:
        return AIC_score(train_y, [train_y.mean()] * len(train_y),model, df=1)
     return AIC_score(train_y, model.predict(train_X[variables]), model)
best_model, best_variables = forward_selection(train_X.columns, train_model, score_
print(best_variables)


# print performance measures (validation data)
regressionSummary(valid_y, best_model.predict(valid_X[best_variables]))

pred_v = pd.Series(best_model.predict(valid_X[best_variables]))
pred_v = pred_v.sort_values(ascending=False)

fig, axes = plt.subplots(nrows=1, ncols=2)
ax = gainsChart(pred_v, ax=axes[0])
ax.set_ylabel('Cumulative Value')
ax.set_title('Cumulative Gains Chart')

ax = liftChart(pred_v, ax=axes[1], labelBars=False)
ax.set_ylabel('Lift')

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

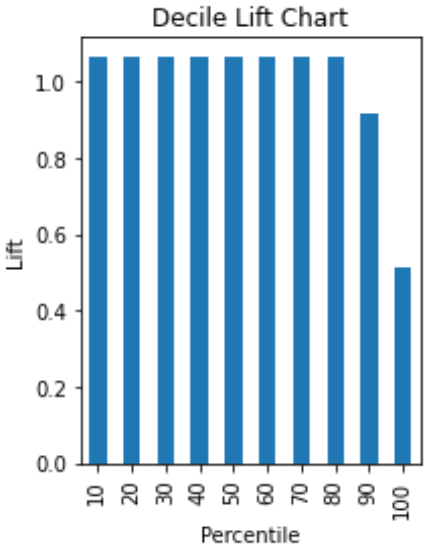
```
Variables: tag_id, step, battery_low
Start: score=18.50, constant
Step: score=18.45, add tag_id
Step: score=18.45, add None
['tag_id']

Regression statistics

               Mean Error (ME) : -0.1643
Root Mean Squared Error (RMSE) : 0.3189
     Mean Absolute Error (MAE) : 0.2812

/var/folders/db/g89vnvfj68l9dp9q6zz747zh0000gn/T/ipykernel_3731/361883891.py:41:
UserWarning: Matplotlib is currently using agg, which is a non-GUI backend, so ca
nnot show the figure.
  plt.show()
```


Cumulative Gains Chart
Cumulative Value
records
0
2
4
6
8
0
5
10
15
20
Decile Lift Chart
Lift
Percentile
0.0
0.2
0.4
0.6
0.8
1.0
10
20
30
40
50
60
70
80
90
100

In [1365]:
```
# Backward Regression (Part C)
from dmba import backward_elimination

def score_model(model, variables):
     return AIC_score(train_y, model.predict(train_X[variables]), model)
allVariables = train_X.columns
best_model, best_variables = backward_elimination(allVariables, train_model, score_
print(best_variables)

# print performance measures (validation data)
regressionSummary(valid_y, best_model.predict(valid_X[best_variables]))

#Backward and forward regression have same regression summary(results) and predict

pred_v = pd.Series(best_model.predict(valid_X[best_variables]))
pred_v = pred_v.sort_values(ascending=False)

fig, axes = plt.subplots(nrows=1, ncols=2)
ax = gainsChart(pred_v, ax=axes[0])
ax.set_ylabel('Cumulative Value')
ax.set_title('Cumulative Gains Chart')

ax = liftChart(pred_v, ax=axes[1], labelBars=False)
ax.set_ylabel('Lift')

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

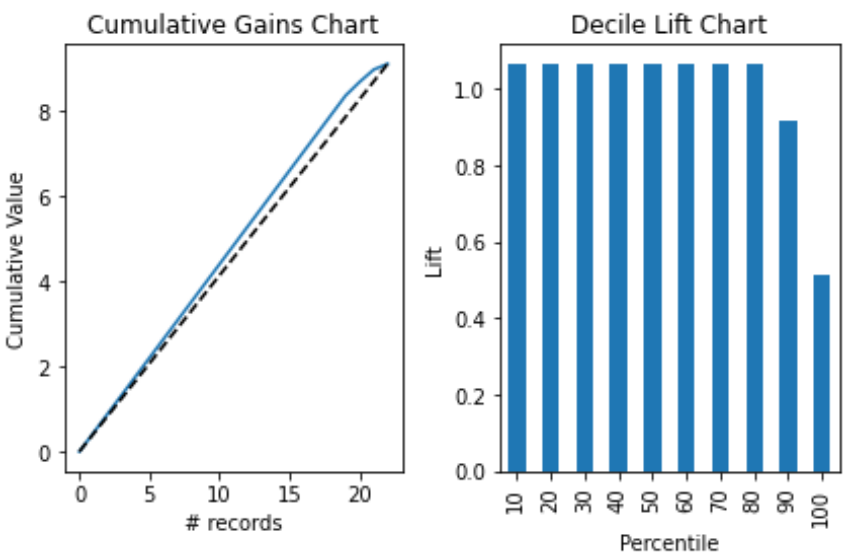
```
Variables: tag_id, step, battery_low
Start: score=22.07
Step: score=20.13, remove battery_low
Step: score=18.45, remove step
['tag_id']

Regression statistics

               Mean Error (ME) : -0.1643
Root Mean Squared Error (RMSE) : 0.3189
     Mean Absolute Error (MAE) : 0.2812

/var/folders/db/g89vnvfj68l9dp9q6zz747zh0000gn/T/ipykernel_3731/178878256.py:27:
UserWarning: Matplotlib is currently using agg, which is a non-GUI backend, so ca
nnot show the figure.
  plt.show()
```


Cumulative Gains Chart
Cumulative Value
records
0
2
4
6
8
0
5
10
15
20


Decile Lift Chart
Lift
Percentile
0.0
0.2
0.4
0.6
0.8
1.0
10
20
30
40
50
60
70
80
90
100

In [1366]:
```
# Both(stepwise regression)
from dmba import stepwise_selection

def train_model(variables):
    if len(variables) == 0:
         return None
    model = LinearRegression()
    model.fit(train_X[variables], train_y)
    return model
def score_model(model, variables):
     if len(variables) == 0:
        return AIC_score(train_y, [train_y.mean()] * len(train_y),model, df=1)
     return AIC_score(train_y, model.predict(train_X[variables]), model)

best_model, best_variables = stepwise_selection(train_X.columns, train_model, score
print(best_variables)
# print performance measures (validation data)
regressionSummary(valid_y, best_model.predict(valid_X[best_variables]))

pred_v = pd.Series(best_model.predict(valid_X[best_variables]))
pred_v = pred_v.sort_values(ascending=False)

fig, axes = plt.subplots(nrows=1, ncols=2)
ax = gainsChart(pred_v, ax=axes[0])
ax.set_ylabel('Cumulative Value')
ax.set_title('Cumulative Gains Chart')

ax = liftChart(pred_v, ax=axes[1], labelBars=False)
ax.set_ylabel('Lift')

plt.tight_layout()
plt.show()

#stepwise also yields same results(predictor and regression statistics)
#three regression methods show that tag_id is the most important predictor for depi
#all hold same statistics and lift chart
#all three yield the same RMSE, therefore all are effective models
#all three improved compared to regular multiple regression from part a, as the RMS
```

```
Variables: tag_id, step, battery_low
Start: score=18.50, constant
Step: score=18.45, add tag_id
Step: score=18.45, unchanged None
['tag_id']

Regression statistics

               Mean Error (ME) : -0.1643
Root Mean Squared Error (RMSE) : 0.3189
     Mean Absolute Error (MAE) : 0.2812

/var/folders/db/g89vnvfj68l9dp9q6zz747zh0000gn/T/ipykernel_3731/3387528008.py:32:
UserWarning: Matplotlib is currently using agg, which is a non-GUI backend, so ca
nnot show the figure.
  plt.show()
```

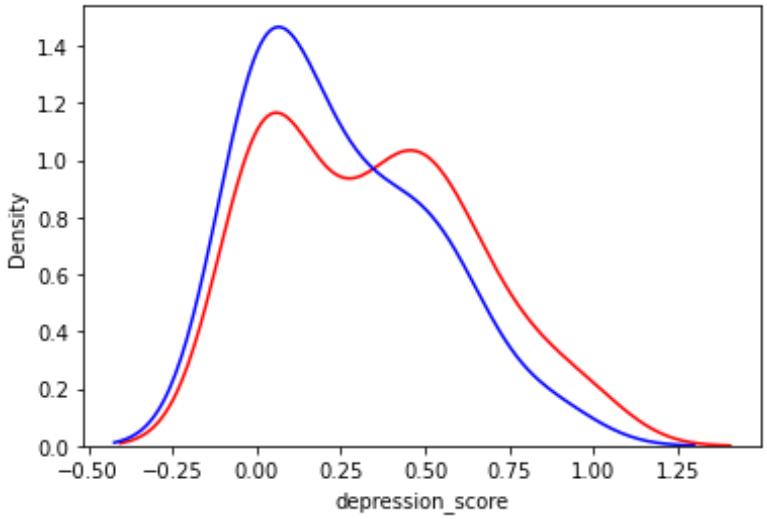

Cumulative Gains Chart
Cumulative Value
records
0
2
4
6
8
0
5
10
15
20
Decile Lift Chart
Lift
Percentile
0.0
0.2
0.4
0.6
0.8
1.0
10
20
30
40
50
60
70
80
90
100

In [1367]:
```
#predicting 495
data495_df = data495_df.iloc[0:53]
predictors = ['tag_0_0','tag_1_0','tag_2_0','tag_3_0','tag_4_0','tag_5_0','tag_6_0'
outcome = 'depression_score'

# partition data 60% training 40% validation
X = pd.get_dummies(data495_df[predictors], drop_first=True)
y = user1_df[outcome]
train_X, valid_X, train_y, valid_y = train_test_split(X, y, test_size=0.4, random_s

depression_lm = LinearRegression()
depression_lm.fit(train_X, train_y)

print(pd.DataFrame({'Predictor': X.columns, 'coefficient': depression_lm.coef_}))
regressionSummary(train_y, depression_lm.predict(train_X))


#the predicted depression score for this user is 0.1308, moderately severe- also sl
#the prediction error(RMSE) is 0.2596

depression =  0.4278355158048195 + (-2.2399e-02*data496_df['tag_0_0']) + (-7.0135e-
+ (1.1102e-16*data496_df['tag_4_0']) + (5.2736e-16*data496_df['tag_5_0']) + (-2.324
+ (0.0000e+00*data496_df['tag_8_0']) + (-4.1685e-01*data496_df['tag_9_0']) + (0.000
+  (1.4923e-01*data496_df['tag_12_0']) + (-2.0125e-05*data496_df['step']) + (-9.034
print(depression.head())

ax1 = sns.distplot(y, hist=False, color="r", label="Actual Value")
sns.distplot(valid_y, hist=False, color="b", label="Fitted Values" , ax=ax1)
```

```
      Predictor   coefficient
0       tag_0_0 -2.239917e-02
1       tag_1_0 -7.013471e-01
2       tag_2_0  4.043185e-01
3       tag_3_0 -4.440892e-16
4       tag_4_0  1.110223e-16
5       tag_5_0  5.273559e-16
6       tag_6_0 -2.324013e-02
7       tag_7_0  0.000000e+00
8       tag_8_0  0.000000e+00
9       tag_9_0 -4.168492e-01
10     tag_10_0  0.000000e+00
11     tag_11_0  6.102884e-01
12     tag_12_0  1.492287e-01
13         step -2.012455e-05
14  battery_low -9.034661e-03

Regression statistics

               Mean Error (ME) : 0.0000
Root Mean Squared Error (RMSE) : 0.2596
     Mean Absolute Error (MAE) : 0.2056
0    0.108407
1    0.108407
2    0.130806
3    0.130806
4    0.130806
dtype: float64

/Users/cynthiazapata/opt/anaconda3/lib/python3.9/site-packages/seaborn/distributi
ons.py:2619: FutureWarning: `distplot` is a deprecated function and will be remov
ed in a future version. Please adapt your code to use either `displot` (a figure-
```

```
level function with similar flexibility) or `kdeplot` (an axes-level function for
kernel density plots).
  warnings.warn(msg, FutureWarning)
/Users/cynthiazapata/opt/anaconda3/lib/python3.9/site-packages/seaborn/distributi
ons.py:2619: FutureWarning: `distplot` is a deprecated function and will be remov
ed in a future version. Please adapt your code to use either `displot` (a figure-
level function with similar flexibility) or `kdeplot` (an axes-level function for
kernel density plots).
  warnings.warn(msg, FutureWarning)
```

Out[1367]: <AxesSubplot:xlabel='depression_score', ylabel='Density'>

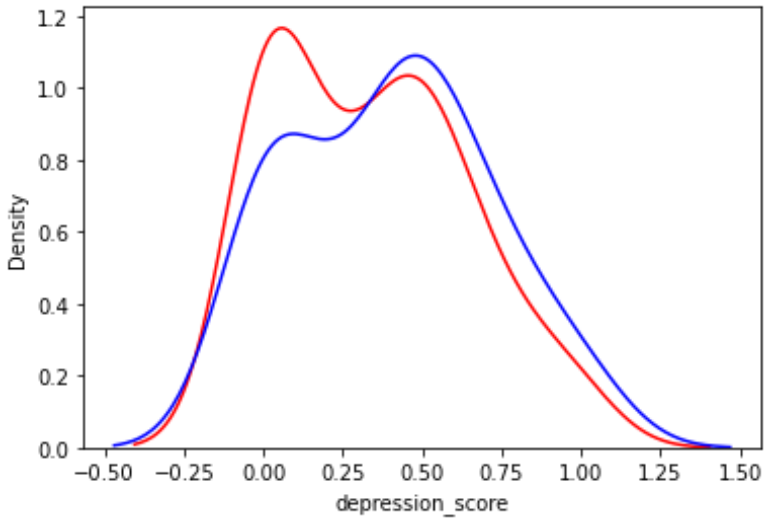


In [1368]:
```
#predicting 496
data496_df = data496_df.iloc[0:53]
predictors = ['tag_0_0','tag_1_0','tag_2_0','tag_3_0','tag_4_0','tag_5_0','tag_6_0'
outcome = 'depression_score'

# partition data 60% training 40% validation
X = pd.get_dummies(data496_df[predictors], drop_first=True)
y = user1_df[outcome]
train_X, valid_X, train_y, valid_y = train_test_split(X, y, test_size=0.4, random_s

depression_lm = LinearRegression()
depression_lm.fit(train_X, train_y)

print(pd.DataFrame({'Predictor': X.columns, 'coefficient': depression_lm.coef_}))
regressionSummary(train_y, depression_lm.predict(train_X))

depression =  0.4278355158048195 + (1.7185e-02*data496_df['tag_0_0']) + (1.7012e-14
+ (-2.7756e-17*data496_df['tag_4_0']) + (0.0000e+00*data496_df['tag_5_0']) + (0.000
+ (0.0000e+00*data496_df['tag_8_0']) + (-4.0958e-02*data496_df['tag_9_0']) + (-2.92
+  (0.0000e+00*data496_df['tag_12_0']) + (-5.6388e-05*data496_df['step']) + (2.7078
print(depression.head())

ax1 = sns.distplot(y, hist=False, color="r", label="Actual Value")
sns.distplot(train_y, hist=False, color="b", label="Fitted Values" , ax=ax1)
#the depression score is 0.7846
#the prediction error(RMSE) is 0.2823
```

```
      Predictor   coefficient
0       tag_0_0  1.718506e-02
1       tag_1_0  1.701243e-14
2       tag_2_0  3.567644e-01
3       tag_3_0  0.000000e+00
4       tag_4_0 -2.775558e-17
5       tag_5_0  0.000000e+00
6       tag_6_0  0.000000e+00
7       tag_7_0  0.000000e+00
8       tag_8_0  0.000000e+00
9       tag_9_0 -4.095791e-02
10     tag_10_0 -2.927913e-01
11     tag_11_0 -4.020022e-02
12     tag_12_0  0.000000e+00
13         step -5.638785e-05
14  battery_low  2.707849e-03

Regression statistics

               Mean Error (ME) : 0.0000
Root Mean Squared Error (RMSE) : 0.2823
     Mean Absolute Error (MAE) : 0.2297
0    0.801781
1    0.801781
2    0.784596
3    0.784596
4    0.784596
dtype: float64

/Users/cynthiazapata/opt/anaconda3/lib/python3.9/site-packages/seaborn/distributi
ons.py:2619: FutureWarning: `distplot` is a deprecated function and will be remov
ed in a future version. Please adapt your code to use either `displot` (a figure-
level function with similar flexibility) or `kdeplot` (an axes-level function for
kernel density plots).
```

```
  warnings.warn(msg, FutureWarning)
/Users/cynthiazapata/opt/anaconda3/lib/python3.9/site-packages/seaborn/distributi
ons.py:2619: FutureWarning: `distplot` is a deprecated function and will be remov
ed in a future version. Please adapt your code to use either `displot` (a figure-
level function with similar flexibility) or `kdeplot` (an axes-level function for
kernel density plots).
  warnings.warn(msg, FutureWarning)
```

Out[1368]: <AxesSubplot:xlabel='depression_score', ylabel='Density'>



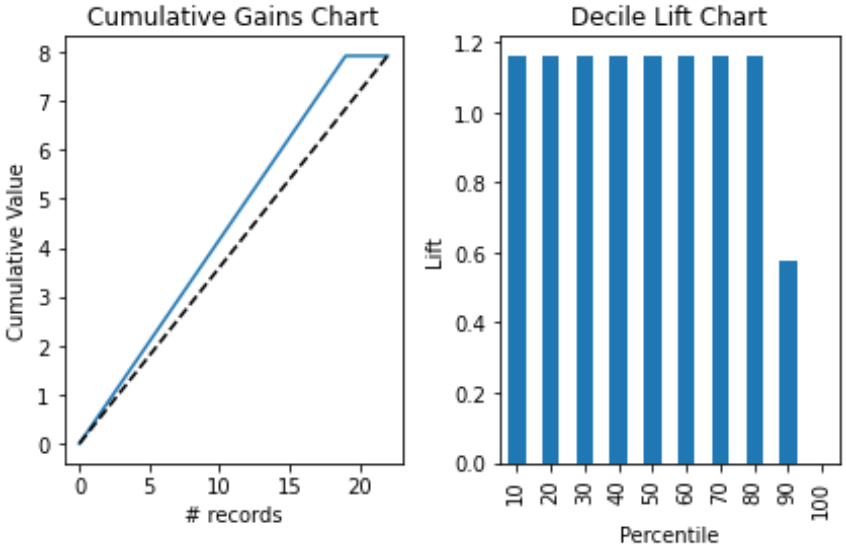
In [1369]:
```
#merge csv files and rename columns
device_df.rename(columns = {'owner_id':'id', 'age':'age'}, inplace = True) #rename
allUsers_df = device_df.merge(user1_df, on = 'id')
allUsers_df.sample(10)
```

Out[1369]:

	Unnamed: 0	uplink_id	id	client_time	tag_id	step	battery_low	is_charge	tag_battery_low	client time	birt yea
20	70	50914	230	2019-12-02 12:29:59	0	1084	92	0	0	2019-12-02 12:29:59	195
29	79	51185	230	2019-12-02 15:09:59	0	5671	84	0	0	2019-12-02 15:09:59	195
27	77	51116	230	2019-12-02 14:29:58	0	4743	86	0	0	2019-12-02 14:29:58	195
17	67	50854	230	2019-12-02 11:35:10	5	654	94	0	0	2019-12-02 11:35:10	195
5	26	367073	230	1970-01-01 00:00:00	0	1552	81	0	0	1970-01-01 00:00:00	195
25	75	50993	230	2019-12-02 14:10:00	0	3583	88	0	0	2019-12-02 14:10:00	195
24	74	50978	230	2019-12-02 13:59:58	0	3152	88	0	0	2019-12-02 13:59:58	195
21	71	50923	230	2019-12-02 12:40:01	0	1186	92	0	0	2019-12-02 12:40:01	195
13	63	50840	230	2019-12-02 11:28:53	4	605	95	0	0	2019-12-02 11:28:53	195
30	80	51204	230	2019-12-02 15:39:59	0	6534	83	0	0	2019-12-02 15:39:59	195

In [1370]:
```
# Backward Regression (Part C)
from dmba import backward_elimination

def score_model(model, variables):
     return AIC_score(train_y, model.predict(train_X[variables]), model)
allVariables = train_X.columns
best_model, best_variables = backward_elimination(allVariables, train_model, score_
print(best_variables)

# print performance measures (validation data)
regressionSummary(valid_y, best_model.predict(valid_X[best_variables]))

#Backward and forward regression have same regression summary(results) and predict

pred_v = pd.Series(best_model.predict(valid_X[best_variables]))
pred_v = pred_v.sort_values(ascending=False)

fig, axes = plt.subplots(nrows=1, ncols=2)
ax = gainsChart(pred_v, ax=axes[0])
ax.set_ylabel('Cumulative Value')
ax.set_title('Cumulative Gains Chart')

ax = liftChart(pred_v, ax=axes[1], labelBars=False)
ax.set_ylabel('Lift')

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

```
Variables: tag_0_0, tag_1_0, tag_2_0, tag_3_0, tag_4_0, tag_5_0, tag_6_0, tag_7_
0, tag_8_0, tag_9_0, tag_10_0, tag_11_0, tag_12_0, step, battery_low
Start: score=43.56
Step: score=41.56, remove tag_0_0
Step: score=39.56, remove tag_3_0
Step: score=37.56, remove tag_4_0
Step: score=35.56, remove tag_1_0
Step: score=33.56, remove tag_12_0
Step: score=31.56, remove tag_5_0
Step: score=29.56, remove tag_6_0
Step: score=27.56, remove tag_7_0
Step: score=25.56, remove tag_8_0
Step: score=23.60, remove tag_11_0
Step: score=21.70, remove tag_9_0
Step: score=20.27, remove battery_low
Step: score=18.96, remove step
Step: score=18.64, remove tag_10_0
['tag_2_0']

Regression statistics

               Mean Error (ME) : -0.1098
Root Mean Squared Error (RMSE) : 0.3348
     Mean Absolute Error (MAE) : 0.2879


/var/folders/db/g89vnvfj68l9dp9q6zz747zh0000gn/T/ipykernel_3731/178878256.py:27:
UserWarning: Matplotlib is currently using agg, which is a non-GUI backend, so ca
nnot show the figure.
  plt.show()
```



In [1371]:
```
#naive bayes classifier with depression class as outcome
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.naive_bayes import MultinomialNB
import matplotlib.pylab as plt
from dmba import classificationSummary, gainsChart

#categorize predictors
allUsers_df.step = allUsers_df.step.astype('category')
allUsers_df['step'] = allUsers_df['step'].astype('category')
allUsers_df.battery_low = allUsers_df.battery_low.astype('category')
allUsers_df['battery_low'] = allUsers_df['battery_low'].astype('category')
allUsers_df.id = allUsers_df.id.astype('category')
allUsers_df['id'] = allUsers_df['id'].astype('category')

predictors = ['step', 'id', 'battery_low']
outcome = 'depression_class'

x = pd.get_dummies(allUsers_df[predictors])
y = allUsers_df['depression_class'].astype('category')
classes = list(y.cat.categories)
```

In [1372]:

```
#split into training and validation
X_train, X_valid, y_train, y_valid = train_test_split(X, y, test_size=0.40, random_
 # run naive Bayes
allUsers_nb = MultinomialNB(alpha=0.01)
allUsers_nb.fit(X_train, y_train)

# predict probabilities
predProb_train = allUsers_nb.predict_proba(X_train)
predProb_valid = allUsers_nb.predict_proba(X_valid)

# predict class membership
y_valid_pred = allUsers_nb.predict(X_valid)
```

In [1373]:
```
# split the original data frame into a train and test using the same random_state
train_df,valid_df = train_test_split(allUsers_df, test_size=0.4, random_state=1)

pd.set_option('precision', 4)
# probability of depression_class

probability = train_df['depression_class'].value_counts() / len(train_df)
print(probability)
#len(train_df)
print()

for predictor in predictors:
    # construct the frequency table
    df = train_df[['depression_class', predictor]]
    freqTable = df.pivot_table(index='depression_class', columns=predictor, aggfunc

    # divide each value by the sum of the row to get conditional probabilities
    propTable = freqTable.apply(lambda x: x / allUsers_df.depression_score.sum(), a
    print(propTable)
    print()
pd.reset_option('precision')
```

```
Normal               0.9032
Moderate             0.0645
Moderately severe    0.0323
Name: depression_class, dtype: float64

step                  421    441    448    472    489    511    523    574  \
depression_class
Moderate              NaN    NaN    NaN    NaN    NaN  0.129    NaN    NaN
Moderately severe     NaN    NaN    NaN    NaN    NaN    NaN    NaN    NaN
Normal              0.129  0.129  0.129  0.129  0.129    NaN  0.129  0.129

step                  615    623  ...   6563   8047   8840  10408  11004  \
depression_class                  ...
Moderate              NaN    NaN  ...    NaN    NaN  0.129    NaN    NaN
Moderately severe     NaN    NaN  ...  0.129    NaN    NaN    NaN    NaN
Normal              0.129  0.129  ...    NaN  0.129    NaN  0.129  0.129

step                13117  13271  13272  14853  15244
depression_class
Moderate              NaN    NaN    NaN    NaN    NaN
Moderately severe     NaN    NaN    NaN    NaN    NaN
Normal              0.129  0.129  0.129  0.129  0.129

[3 rows x 31 columns]

id                    230    486    496    504     544    547    665
depression_class
Moderate              NaN  0.129    NaN  0.129     NaN    NaN    NaN
Moderately severe     NaN    NaN  0.129    NaN     NaN    NaN    NaN
Normal             3.0968    NaN    NaN    NaN  0.2581  0.129  0.129

battery_low             8     37     53     75     78     80     81     83  \
depression_class
Moderate              NaN    NaN  0.129    NaN    NaN    NaN    NaN    NaN
Moderately severe     NaN    NaN    NaN    NaN    NaN    NaN    NaN    NaN
Normal              0.129  0.129    NaN  0.129  0.129  0.129  0.129  0.129
```

```
battery_low             84     85  ...      88     89     90     92     94  \
depression_class                   ...
Moderate               NaN    NaN  ...  0.1290    NaN    NaN    NaN    NaN
Moderately severe      NaN  0.129  ...     NaN    NaN    NaN    NaN    NaN
Normal               0.129  0.129  ...  0.2581  0.129  0.129  0.129  0.129

battery_low             95     96      97      98      99
depression_class
Moderate               NaN    NaN     NaN     NaN     NaN
Moderately severe      NaN    NaN     NaN     NaN     NaN
Normal               0.3871  0.129  0.2581  0.3871  0.2581

[3 rows x 21 columns]
```

In [1374]:
```
## cutoff = 0.9032
predicted = ['Normal' if p >= .9032 else 'Moderate' for p in allUsers_df.depressior
classificationSummary(allUsers_df.depression_class, predicted, ['Moderate', 'Modera
```

```
Confusion Matrix (Accuracy 0.0377)

                 Prediction
          Actual          Moderate Moderately severe            Normal
        Moderate                 2                  0                 0
Moderately severe                2                  0                 0
          Normal                49                  0                 0
```

In [1375]:
```
## cutoff = 0.0645
predicted = ['Moderate' if p >= 0.0645 else 'Moderately sevevre' for p in allUsers_
classificationSummary(allUsers_df.depression_class, predicted, ['Moderate', 'Modera
```

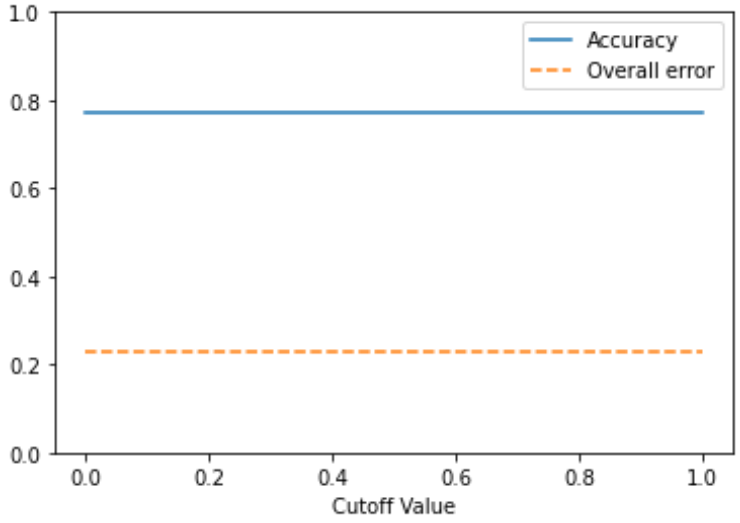
```
Confusion Matrix (Accuracy 0.0377)

                 Prediction
          Actual          Moderate Moderately severe            Normal
        Moderate                 2                  0                 0
Moderately severe                2                  0                 0
          Normal                 0                  0                 0
```

In [1376]:
```
## cutoff = .0323
predicted = ['Moderately severe' if p >= 0.0323 else 'None' for p in allUsers_df.de
classificationSummary(allUsers_df.depression_class, predicted, ['Moderate', 'Modera
```

```
Confusion Matrix (Accuracy 0.0377)

                 Prediction
          Actual          Moderate Moderately severe            Normal
        Moderate                 0                  2                 0
Moderately severe                0                  2                 0
          Normal                 0                  0                 0
```

In [1377]:
```
cutoffs = [i * 0.1 for i in range(0, 11)]
accT = []
for cutoff in cutoffs:
    predicted = [1 if p > cutoff else 0 for p in probability]
    accT.append(accuracy_score(y_valid, y_valid_pred))

line_accuracy = plt.plot(cutoffs, accT, '-', label='Accuracy')[0]
line_error = plt.plot(cutoffs, [1 - acc for acc in accT], '--', label='Overall erro
plt.ylim([0,1])
plt.xlabel('Cutoff Value')
plt.legend(handles=[line_accuracy, line_error])
plt.show()
```

```
/var/folders/db/g89vnvfj68l9dp9q6zz747zh0000gn/T/ipykernel_3731/62658708.py:12: U
serWarning: Matplotlib is currently using agg, which is a non-GUI backend, so can
not show the figure.
  plt.show()
```



In [1378]:
```
from sklearn.metrics import roc_curve, auc
# compute ROC curve and AUC for specificity and sensitivity
fpr, tpr, _ = roc_curve(y_valid, y_valid_pred, pos_label=1)
roc_auc = auc(fpr, tpr)

plt.figure(figsize=[5, 5])
plt.plot(fpr, tpr, color='darkorange',
         lw=2, label='ROC curve (area = %0.4f)' % roc_auc)
plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate (1 - Specificity)')
plt.ylabel('True Positive Rate (Sensitivity)')
plt.legend(loc="lower right")
```

```
---------------------------------------------------------------------------
UFuncTypeError                            Traceback (most recent call last)
/var/folders/db/g89vnvfj68l9dp9q6zz747zh0000gn/T/ipykernel_3731/2996704188.py in
<module>
      1 from sklearn.metrics import roc_curve, auc
      2 # compute ROC curve and AUC for specificity and sensitivity
----> 3 fpr, tpr, _ = roc_curve(y_valid, y_valid_pred, pos_label=1)
      4 roc_auc = auc(fpr, tpr)
      5

~/opt/anaconda3/lib/python3.9/site-packages/sklearn/utils/validation.py in inner_
f(*args, **kwargs)
     61             extra_args = len(args) - len(all_args)
     62             if extra_args <= 0:
---> 63                 return f(*args, **kwargs)
     64
     65             # extra_args > 0

~/opt/anaconda3/lib/python3.9/site-packages/sklearn/metrics/_ranking.py in roc_cu
rve(y_true, y_score, pos_label, sample_weight, drop_intermediate)
    911
    912     """
--> 913     fps, tps, thresholds = _binary_clf_curve(
    914         y_true, y_score, pos_label=pos_label, sample_weight=sample_weigh
t)
    915

~/opt/anaconda3/lib/python3.9/site-packages/sklearn/metrics/_ranking.py in _binar
y_clf_curve(y_true, y_score, pos_label, sample_weight)
    717     # the indices associated with the distinct values. We also
    718     # concatenate a value for the end of the curve.
--> 719     distinct_value_indices = np.where(np.diff(y_score))[0]
    720     threshold_idxs = np.r_[distinct_value_indices, y_true.size - 1]
    721

<__array_function__ internals> in diff(*args, **kwargs)

~/opt/anaconda3/lib/python3.9/site-packages/numpy/lib/function_base.py in diff(a,
n, axis, prepend, append)
   1279     op = not_equal if a.dtype == np.bool_ else subtract
   1280     for _ in range(n):
-> 1281         a = op(a[slice1], a[slice2])
   1282
   1283     return a
```

```
UFuncTypeError: ufunc 'subtract' did not contain a loop with signature matching t
ypes (dtype('<U17'), dtype('<U17')) -> dtype('<U17')
```

In [ ]:
```
# probability of a u(ser having 'moderately severe' depression when their average t
# 0.03757 (as shown below)
df = pd.concat([pd.DataFrame({'actual': y_valid, 'predicted': y_valid_pred}),
                pd.DataFrame(predProb_valid, index=y_valid.index)], axis=1)
mask = ((X_valid.step >= 1000)& (y_valid == "Moderately severe"))

df[mask]
```

Out[1298]:

	actual	predicted	0	1	2
46	Moderately severe	Moderately severe	0.03757	0.96243	1.080246e-32

In [ ]:
```
df = pd.DataFrame({'actual': 1 - y_valid.cat.codes, 'prob': predProb_valid[:, 0]})
df = df.sort_values(by=['prob'], ascending=False).reset_index(drop=True)

fig, ax = plt.subplots()
fig.set_size_inches(4, 4)
gainsChart(df.actual, ax=ax)
```

Out[1345]:
```
<AxesSubplot:xlabel='# records', ylabel='# cumulative gains'>
```