Logistic regression

Dataset:

German Credit

Objective

Estimate default probabilities using logistic regression

1. Load Libraries and data

In [2]:

```
#Load Libraries
import pandas as pd
import numpy as np
import matplotlib as mpl
import matplotlib.pyplot as plt
from sklearn.cross_validation import train_test_split
from sklearn import linear_model
import statsmodels.api as sm
from sklearn import metrics
from sklearn import datasets
import seaborn as sn
%matplotlib inline
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\cross_validation.py:41: D
eprecationWarning: This module was deprecated in version 0.18 in favor of th
e model_selection module into which all the refactored classes and functions
are moved. Also note that the interface of the new CV iterators are differen
t from that of this module. This module will be removed in 0.20.
  "This module will be removed in 0.20.", DeprecationWarning)
```

In [3]:

```
#Load data
credit_df = pd.read_excel('GermanCredit.xlsx')
```

In [4]:

```
#Print header of the file
credit_df.head()
```

Out[4]:

	Creditability	CreditAmount	DurationOfCreditInMonths
0	1	1049	18
1	1	2799	9
2	1	841	12
3	1	2122	12
4	1	2171	12

2. Check how many records do we have

In [5]:

```
credit_df.shape
```

Out[5]:

```
(1000, 3)
```

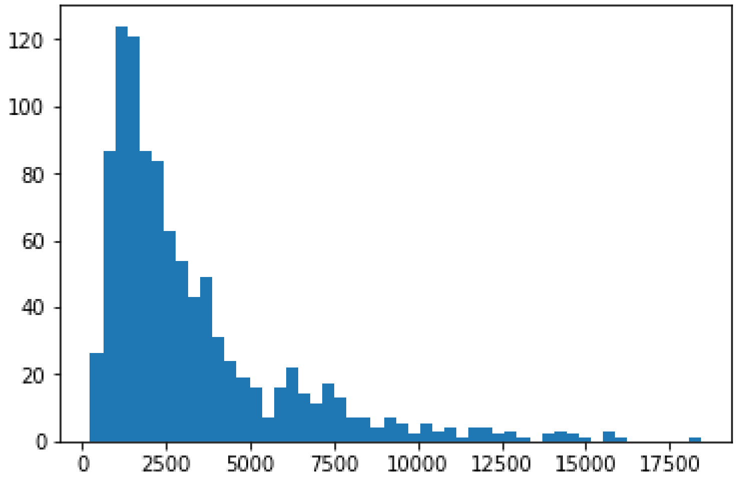
3. Plot Histogram for column 'CreditAmount'

In [6]:

```
plt.hist(credit_df['CreditAmount'], 50)
```

Out[6]:

```
(array([ 26.,  87., 124., 121.,  87.,  84.,  63.,  54.,  43.,  49.,  31.,
         24.,  19.,  16.,   7.,  16.,  22.,  14.,  11.,  17.,  13.,   7.,
          7.,   4.,   7.,   5.,   2.,   5.,   3.,   4.,   1.,   4.,   4.,
          2.,   3.,   1.,   0.,   2.,   3.,   2.,   1.,   0.,   3.,   1.,
          0.,   0.,   0.,   0.,   0.,   1.]),
 array([  250.  ,   613.48,   976.96,  1340.44,  1703.92,  2067.4 ,
         2430.88,  2794.36,  3157.84,  3521.32,  3884.8 ,  4248.28,
         4611.76,  4975.24,  5338.72,  5702.2 ,  6065.68,  6429.16,
         6792.64,  7156.12,  7519.6 ,  7883.08,  8246.56,  8610.04,
         8973.52,  9337.  ,  9700.48, 10063.96, 10427.44, 10790.92,
        11154.4 , 11517.88, 11881.36, 12244.84, 12608.32, 12971.8 ,
        13335.28, 13698.76, 14062.24, 14425.72, 14789.2 , 15152.68,
        15516.16, 15879.64, 16243.12, 16606.6 , 16970.08, 17333.56,
        17697.04, 18060.52, 18424.  ]),
 <a list of 50 Patch objects>)
```



In [7]:

```
amountIntervalsPoints = np.array([0, 500, 1000,1500,2000, 2500, 5000, 7500, 10000, 15000, 2
amountIntervals = [(amountIntervalsPoints[i] + int(i != 0), amountIntervalsPoints[i + 1]) f
amountIntervals
```

Out[7]:

```
[(0, 500),
 (501, 1000),
 (1001, 1500),
 (1501, 2000),
 (2001, 2500),
 (2501, 5000),
 (5001, 7500),
 (7501, 10000),
 (10001, 15000),
 (15001, 20000)]
```

In [8]:

```
amountIntervalsDf = pd.DataFrame(amountIntervals, columns = ['intervalLeftSide', 'intervalR
amountIntervalsDf
```

Out[8]:

	intervalLeftSide	intervalRightSide
0	0	500
1	501	1000
2	1001	1500
3	1501	2000
4	2001	2500
5	2501	5000
6	5001	7500
7	7501	10000
8	10001	15000
9	15001	20000

In [9]:

```
#Credibility table preparation
Credibility0 = []
Credibility1 = []
for interval in amountIntervals:
    subData = credit_df[credit_df.CreditAmount >= interval[0]]
    subData = subData[subData.CreditAmount <= interval[1]]
    Credibility0.append(sum(subData.Creditability == 0))
    Credibility1.append(sum(subData.Creditability == 1))
```

3. Create creditability dataframe

In [10]:

```
tempDf = pd.DataFrame(np.column_stack([Credibility0, Credibility1]), columns = ['Credibilii
tempDf
```

Out[10]:

	Credibiliity0	Credibiliity1
0	3	15
1	34	64
2	51	139
3	33	93
4	26	79
5	75	200
6	34	68
7	20	26
8	21	14
9	3	2

4. Concatenate the above 2 dataframes and give the total of Credibiliity0 and Credibiliity1

In [11]:

```
compareCreditWorthinessDf = pd.concat([amountIntervalsDf.reset_index(drop=True), tempDf], a
compareCreditWorthinessDf
compareCreditWorthinessDf['total'] = compareCreditWorthinessDf.Credibiliity0 + compareCredi
compareCreditWorthinessDf
```

Out[11]:

	intervalLeftSide	intervalRightSide	Credibiliity0	Credibiliity1	total
0	0	500	3	15	18
1	501	1000	34	64	98
2	1001	1500	51	139	190
3	1501	2000	33	93	126
4	2001	2500	26	79	105
5	2501	5000	75	200	275
6	5001	7500	34	68	102
7	7501	10000	20	26	46
8	10001	15000	21	14	35
9	15001	20000	3	2	5

5. Plot Creditworthiness plot for Credibility == 0 and

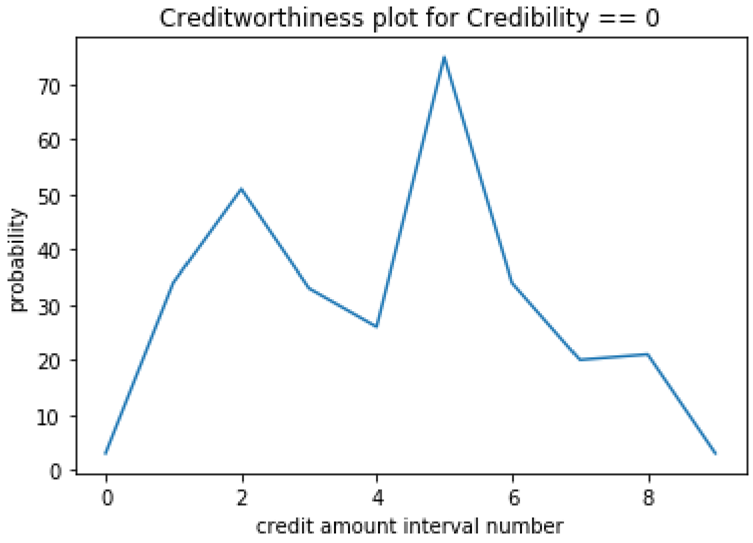
also ==1

In [12]:

```
plt.plot(compareCreditWorthinessDf.Credibiliity0)
plt.xlabel('credit amount interval number')
plt.ylabel('probability')
plt.title("Creditworthiness plot for Credibility == 0")
```

Out[12]:

```
Text(0.5,1,'Creditworthiness plot for Credibility == 0')
```

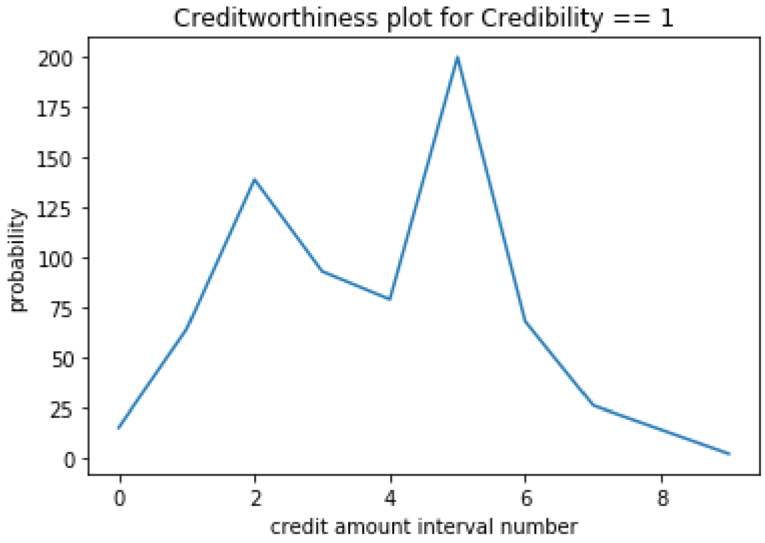


In [13]:

```
plt.plot(compareCreditWorthinessDf.Credibiliity1)
plt.xlabel('credit amount interval number')
plt.ylabel('probability')
plt.title("Creditworthiness plot for Credibility == 1")
```

Out[13]:

```
Text(0.5,1,'Creditworthiness plot for Credibility == 1')
```



6. Prepare input data for the model

In [16]:

```
X = np.array(credit_df.CreditAmount)
Y = credit_df.Creditability.astype('category')
```

7. Fit logistic regression model

In [20]:

```
X_train, X_test, y_train, y_test = train_test_split( X, Y, test_size = 0.3, random_state =
logit = sm.Logit( y_train, sm.add_constant( X_train ) )
lg = logit.fit()
lg.summary2()
```

```
Optimization terminated successfully.
         Current function value: 0.598243
         Iterations 5
```

Out[20]:

Model:	Logit	Pseudo R-squared:	0.017
Dependent Variable:	Creditability	AIC:	841.5402
Date:	2018-11-07 21:47	BIC:	850.6424
No. Observations:	700	Log-Likelihood:	-418.77
Df Model:	1	LL-Null:	-425.90
Df Residuals:	698	LLR p-value:	0.00015977
Converged:	1.0000	Scale:	1.0000
No. Iterations:	5.0000		

	Coef.	**Std.Err.**	**z**	**P>|z|**	**[0.025**	**0.975]**
const	1.2287	0.1307	9.4037	0.0000	0.9726	1.4848
x1	-0.0001	0.0000	-3.7764	0.0002	-0.0002	-0.0001

8. Test accuracy calculation

In [22]:

```
def get_predictions( y_test, model ):
    y_pred_df = pd.DataFrame( { 'actual': y_test,
                               "predicted_prob": lg.predict( sm.add_constant( X_test ) ) }
    return y_pred_df

X_test[0:5]
```

Out[22]:

```
array([10974,  1149,  1736,  1414,  2978], dtype=int64)
```

In [23]:

```
y_pred_df = get_predictions(X_test, lg )
y_pred_df['originalCredibility'] = np.array(y_test)
y_pred_df[0:5]
```

Out[23]:

```
   actual  predicted_prob  originalCredibility
0   10974        0.515795                    0
1    1149        0.751504                    1
2    1736        0.739680                    1
3    1414        0.746211                    1
4    2978        0.713492                    1
```

In [24]:

```
y_pred_df['predicted'] = y_pred_df.predicted_prob.map( lambda x: 1 if x > 0.6 else 0)
y_pred_df[0:10]
```

Out[24]:

```
   actual  predicted_prob  originalCredibility  predicted
0   10974        0.515795                    0          0
1    1149        0.751504                    1          1
2    1736        0.739680                    1          1
3    1414        0.746211                    1          1
4    2978        0.713492                    1          1
5    2728        0.718888                    1          1
6    2859        0.716068                    1          1
7    3832        0.694598                    1          1
8     727        0.759779                    0          1
9    1318        0.748137                    1          1
```

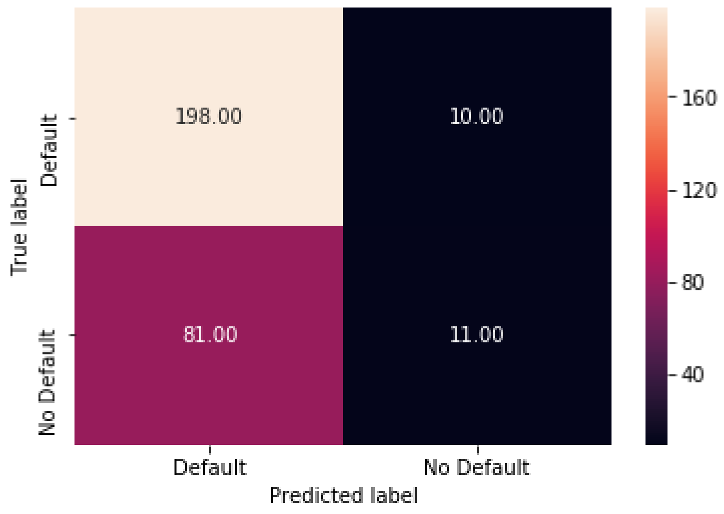
9. Build a confusion matrix

In [26]:

```
def draw_cm( actual, predicted ):
    cm = metrics.confusion_matrix( actual, predicted, [1,0] )
    sn.heatmap(cm, annot=True,  fmt='.2f', xticklabels = ["Default", "No Default"] , ytickl
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
    plt.show()
```

In [28]:

```
draw_cm( y_pred_df.originalCredibility, y_pred_df.predicted )
```



In [30]:

```
print( 'Total Accuracy : ',np.round( metrics.accuracy_score( y_test, y_pred_df.predicted ),
```

```
Total Accuracy :  0.7
```

10. Predicted Probability distribution Plots for Defaults and Non Defaults

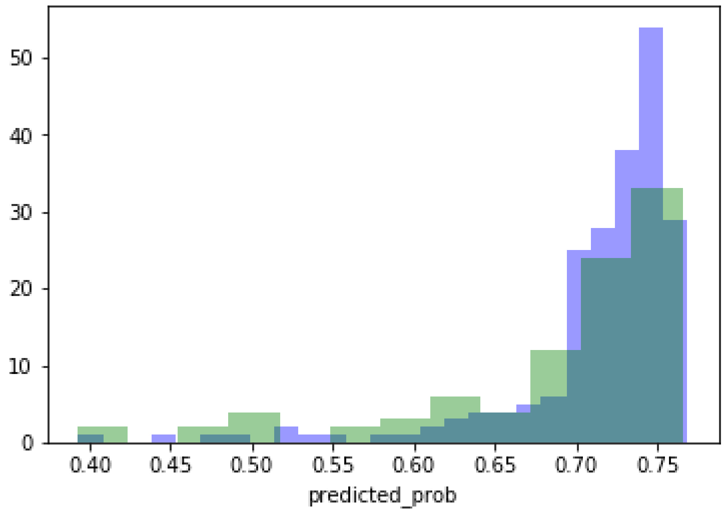
In [29]:

```
sn.distplot( y_pred_df[y_pred_df.originalCredibility == 1]["predicted_prob"], kde=False, co
sn.distplot( y_pred_df[y_pred_df.originalCredibility == 0]["predicted_prob"], kde=False, co
```

```
C:\ProgramData\Anaconda3\lib\site-packages\matplotlib\axes\_axes.py:6462: Us
erWarning: The 'normed' kwarg is deprecated, and has been replaced by the 'd
ensity' kwarg.
  warnings.warn("The 'normed' kwarg is deprecated, and has been "
C:\ProgramData\Anaconda3\lib\site-packages\matplotlib\axes\_axes.py:6462: Us
erWarning: The 'normed' kwarg is deprecated, and has been replaced by the 'd
ensity' kwarg.
  warnings.warn("The 'normed' kwarg is deprecated, and has been "
```

Out[29]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x14e0c2ed128>
```


predicted_prob