Predicting Credit Card Default Using Machine Learning

Jesse Mailhot | Mentor: Shmuel Naaman | Springboard Data Science Career Track

1/21/2019

Contents

Introduction

In this project, I aim to solve the following problems:

- Which features are the best predictor of default?
- What is the relationship between default and other features?
    - Marital status, education level, gender, etc…

Dataset

Credit Card Default

- Demographic data: sex, marital status, education level, age
- Payment data: credit limit, bill amount, payment amount, payment delay
- April - September, 2005
- 30,000 Taiwanese credit card customers.

Source: UCI Machine Learning Repository

Data Wrangling

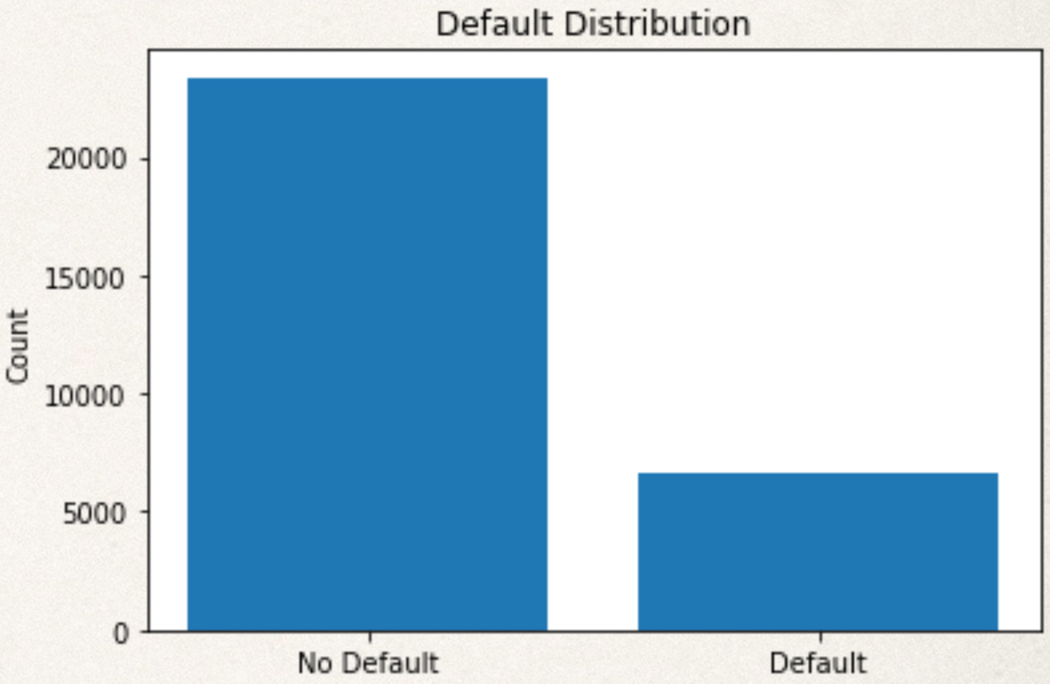
- Change SEX to 0 & 1
- Change unlabeled EDUCATION values to ‘other’
- Change unlabeled MARRIAGE values to ‘other’
- Binarize PAY_0 - PAY_6

Data Analysis

- Investigate each variable in relation to default
- Look for trends and outliers

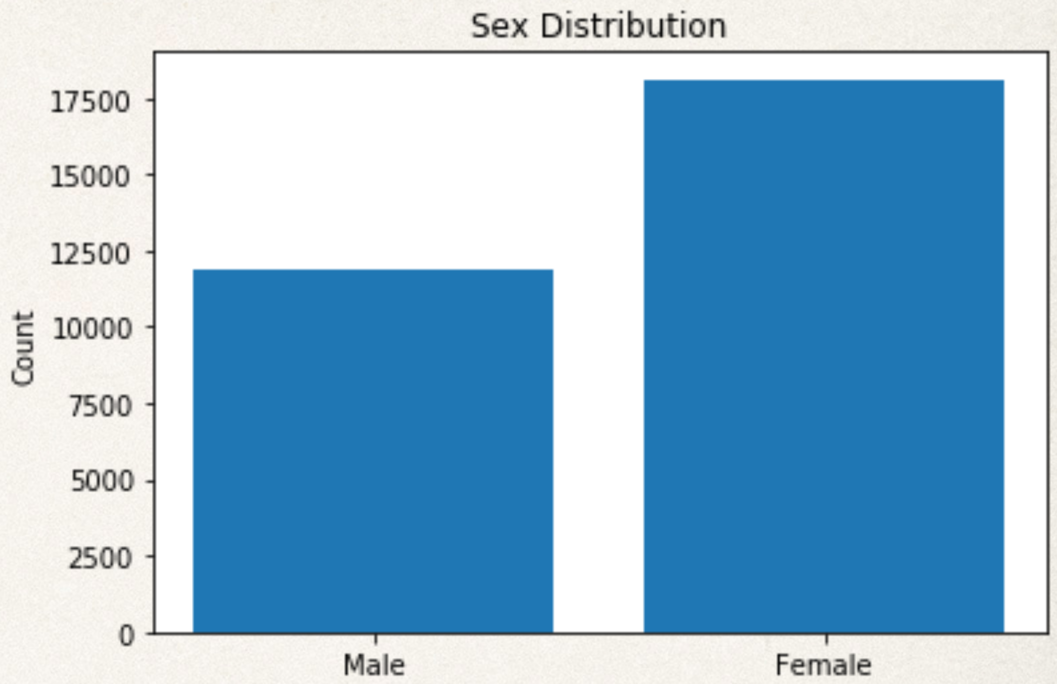
Default

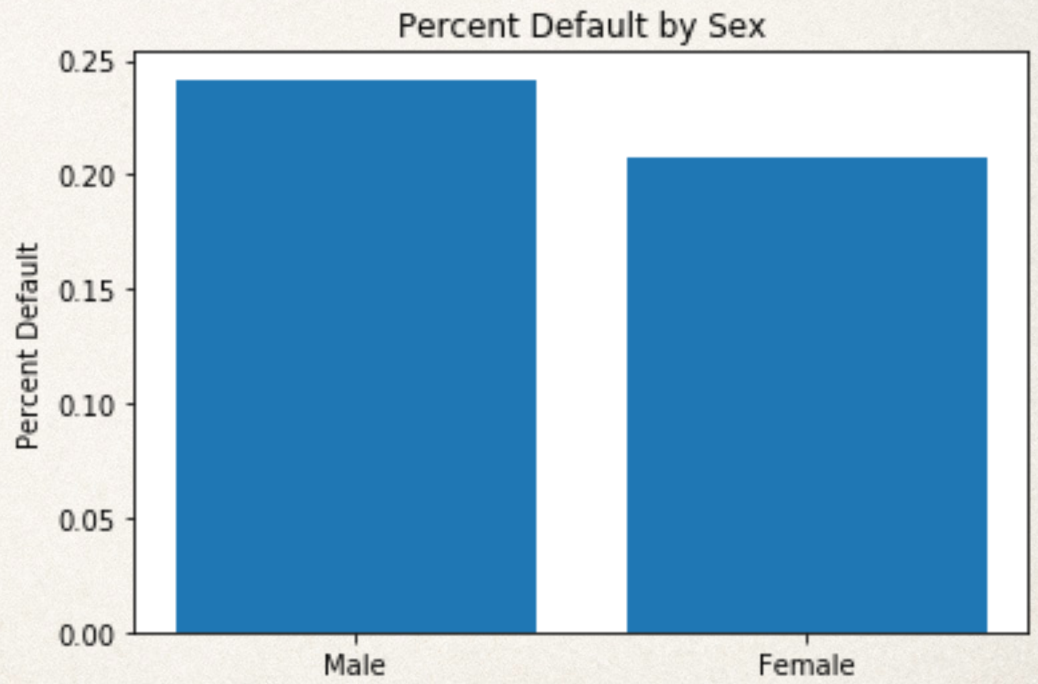
- Unbalanced dataset
- 22.12% default percentage



Sex

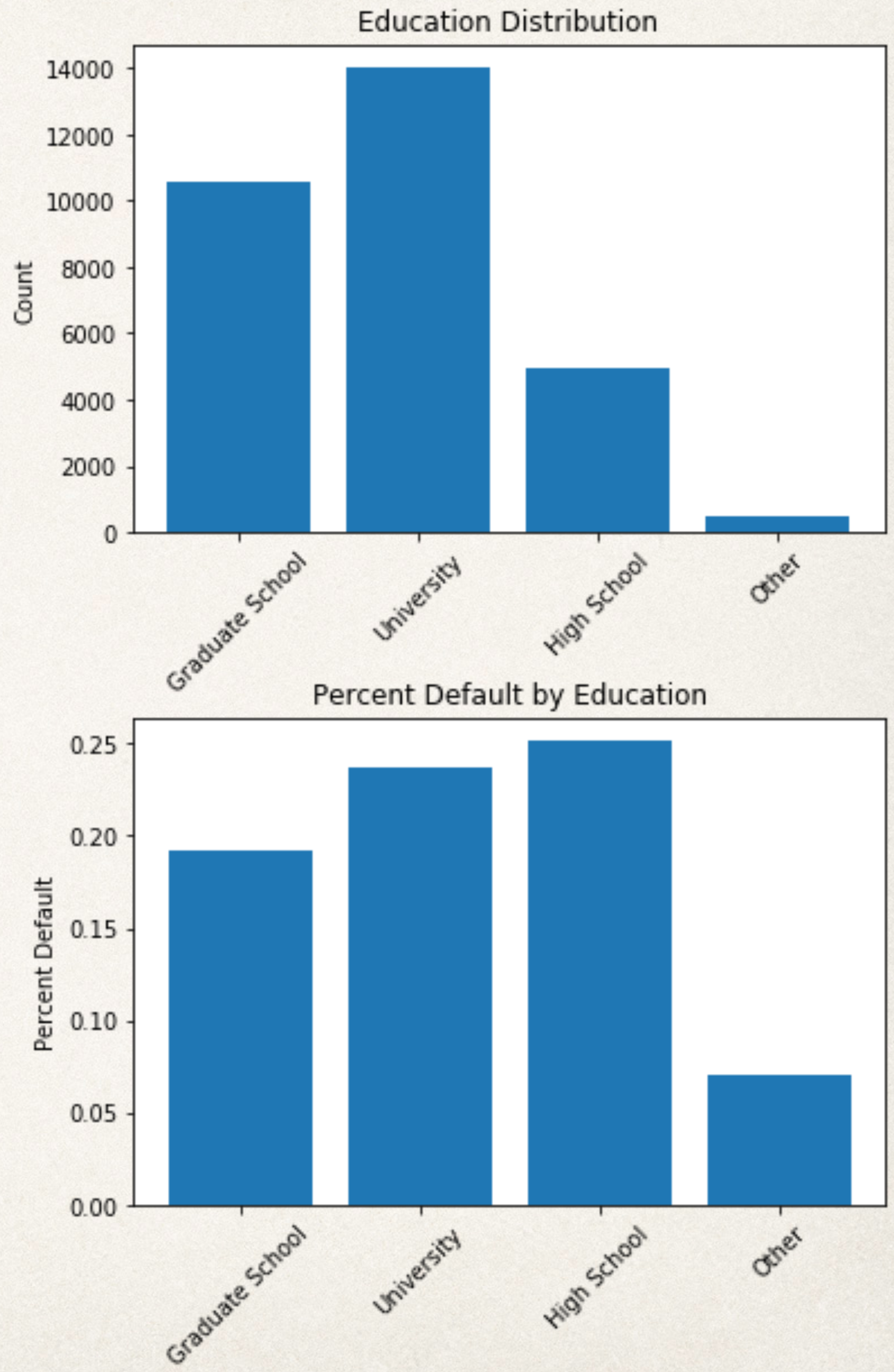
- More female clients than male clients
- Male clients have higher chance of default
- Chi-squared test results:
  -Test statistic 47.71
  -P-value 4.94e^{-12}





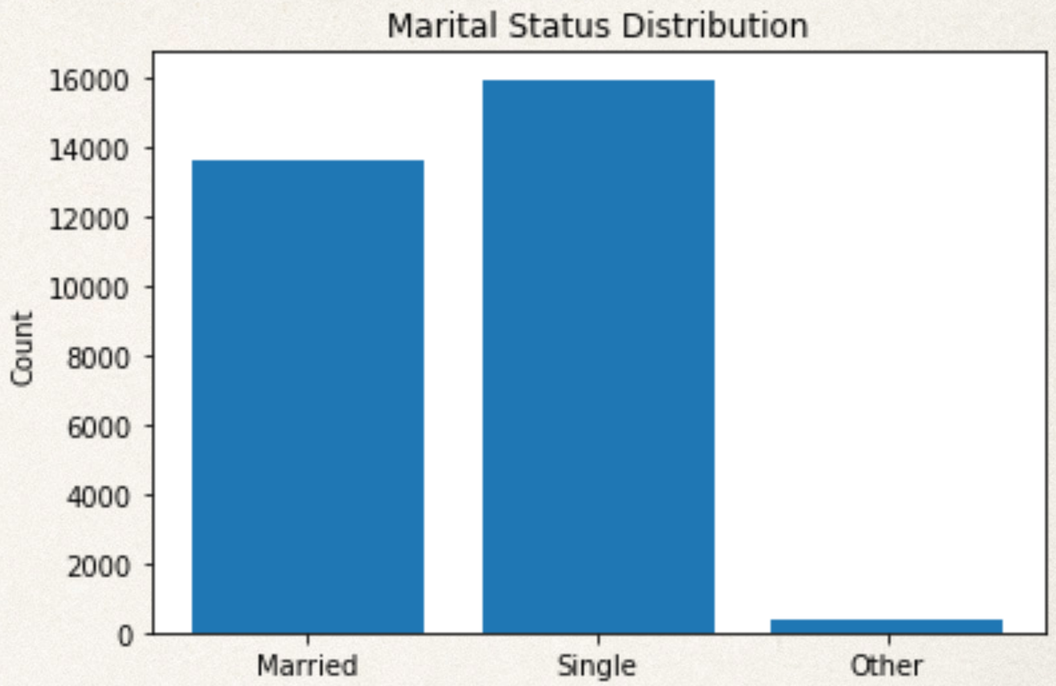
Education

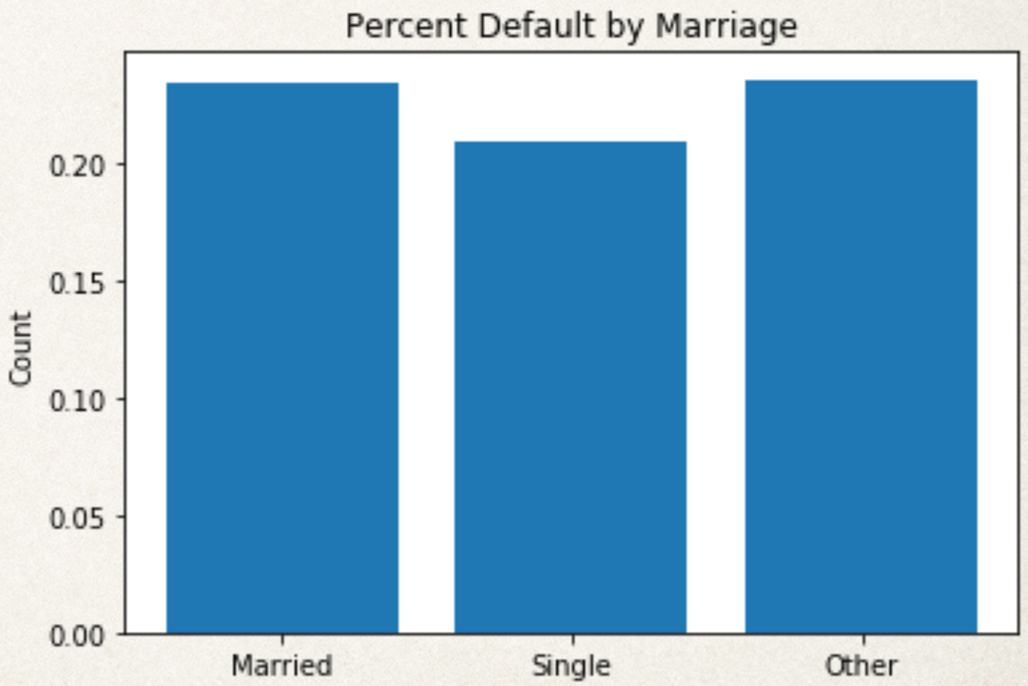
- Negative correlation between education level and default
- Low sample size - Other
- Chi-squared test results:
  -Test statistic 160.41
  -P-value 1.50e^{-34}



Marriage

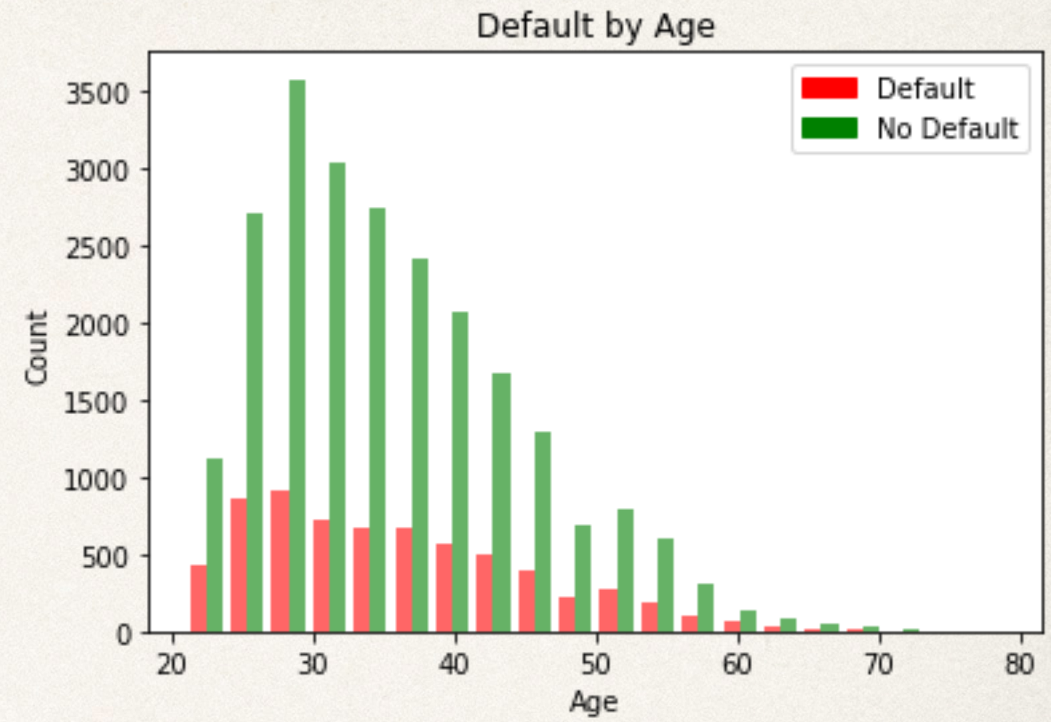
- Single has lower percent default than married
- Low sample size - Other
  - Other = divorced?
- Chi-squared test results:
  -Test statistic 28.13
  -P-value 7.79e^{-7}

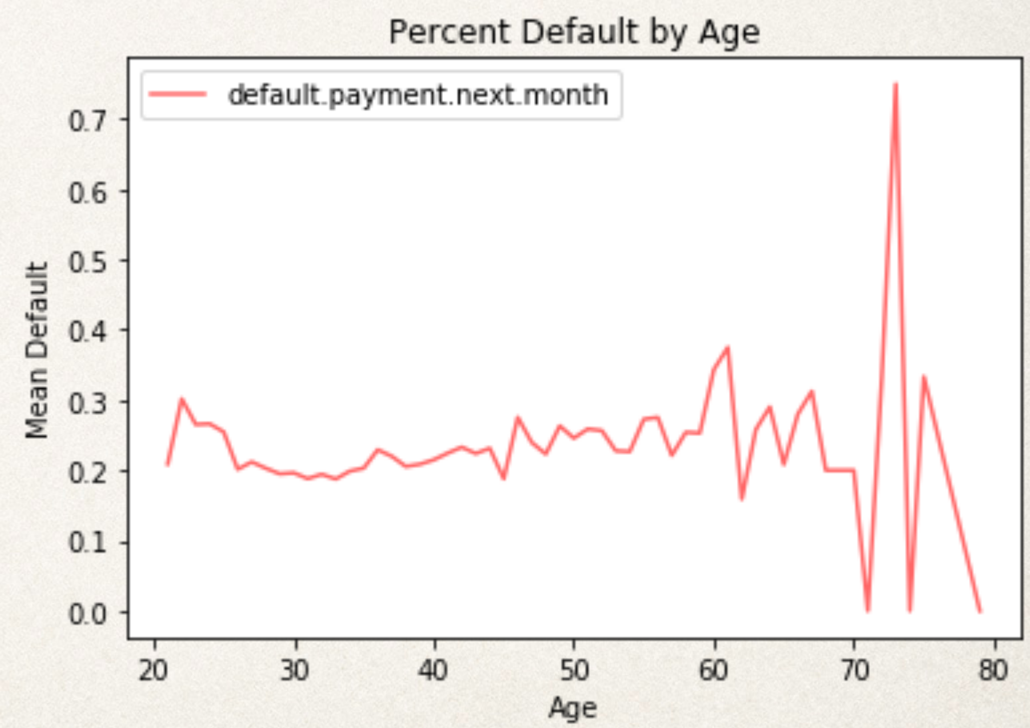




Age

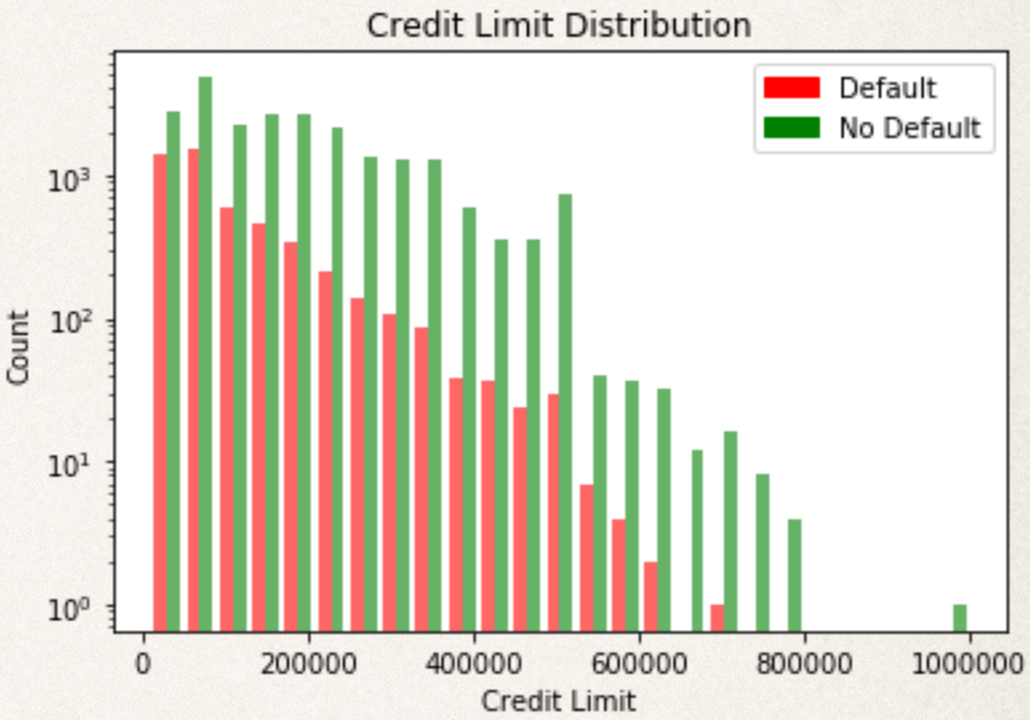
- Default highest in ages 20-25
  - Decreases after 25
  - Increases after 35
- Low sample size for ages 50+
- T-test results:
  -Test statistic -2.41
  -P-value 0.016





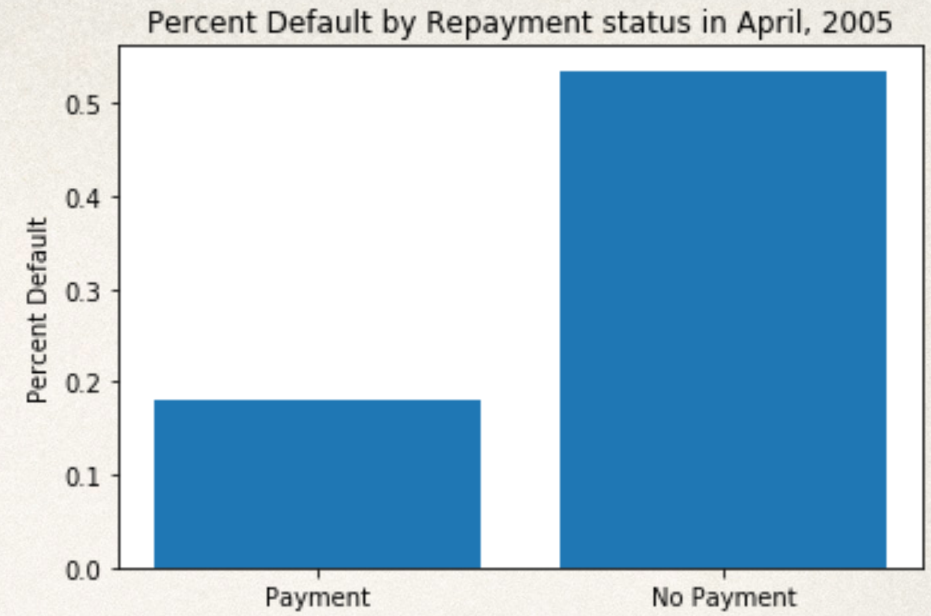
Credit Limit

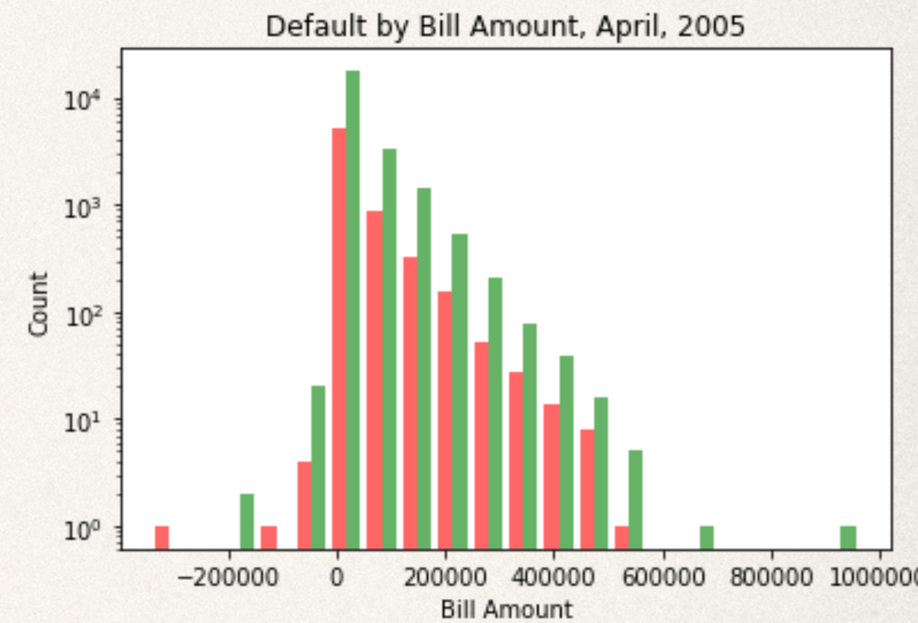
- Mean credit limit for defaulting clients is NT$47990 lower than non-defaulting clients
- T-test results:
  -Test statistic 26.91
  -P-value $1.30e^{-157}$

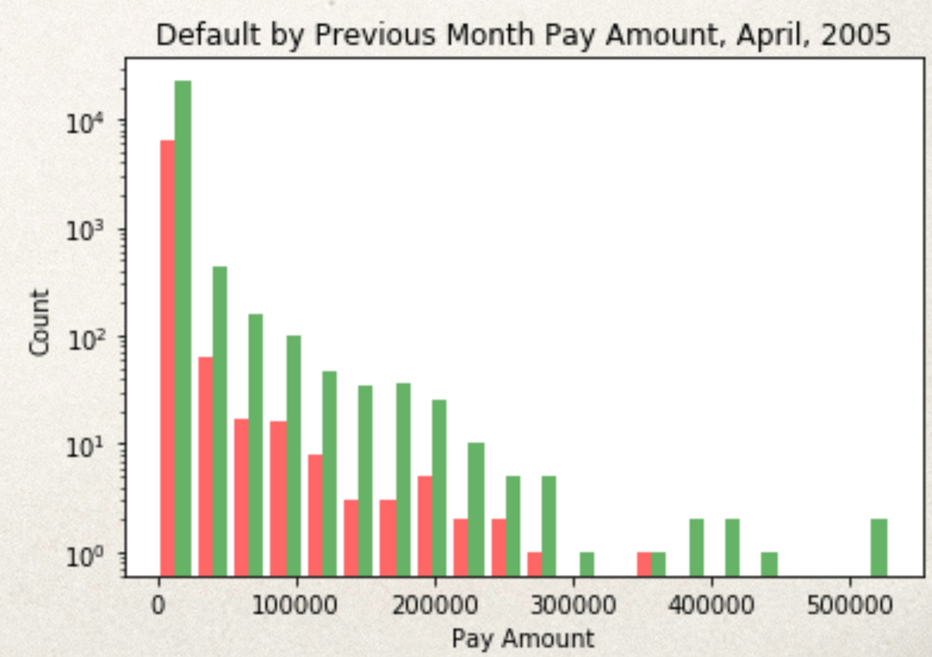


Pay Data
April, 2005

- 18.67% of paying clients defaulted
- Clients with bill amount 0 or less defaulted (?)
- Negative correlation between pay amount and default
- T-test results (bill amount):
  -Test statistic 0.930
  -P-value 0.352
- T-test results (pay amount):
  -Test statistic 9.22
  -P-value $3.03e^{-20}$

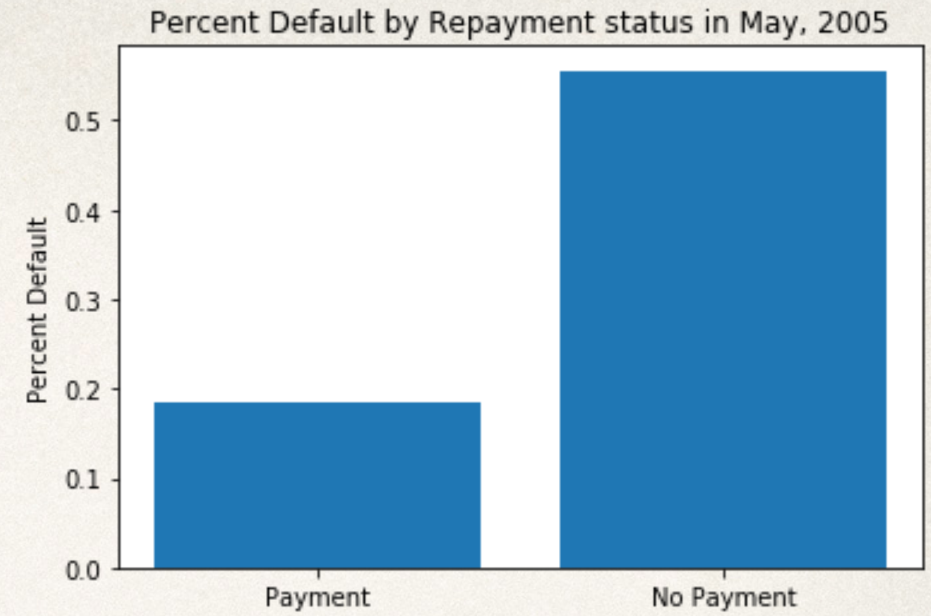


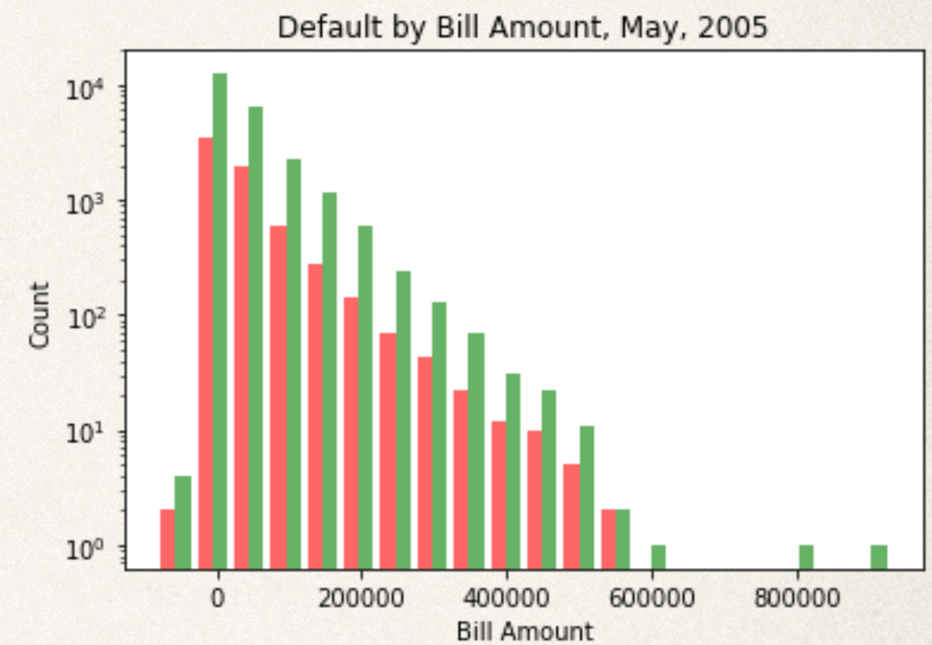


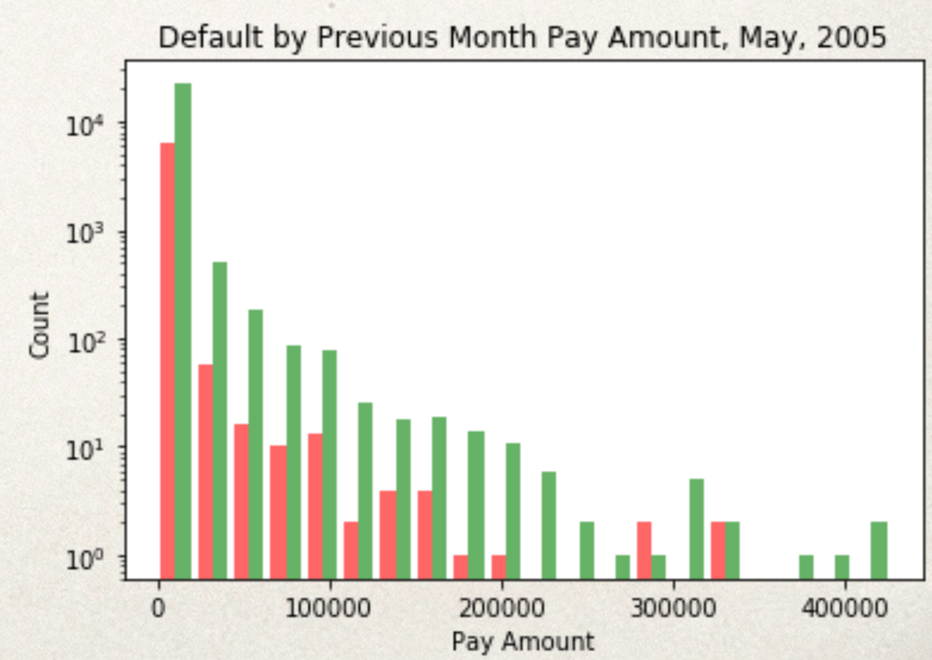


Pay Data
May, 2005

- 18.45% of paying clients defaulted
- Clients with bill amount 0 or less defaulted (?)
- Negative correlation between pay amount and default
- T-test results (bill amount):
  -Test statistic 1.17
  -P-value 0.241
- T-test results (pay amount):
  -Test statistic 9.56
  -P-value 1.24e^{-21}

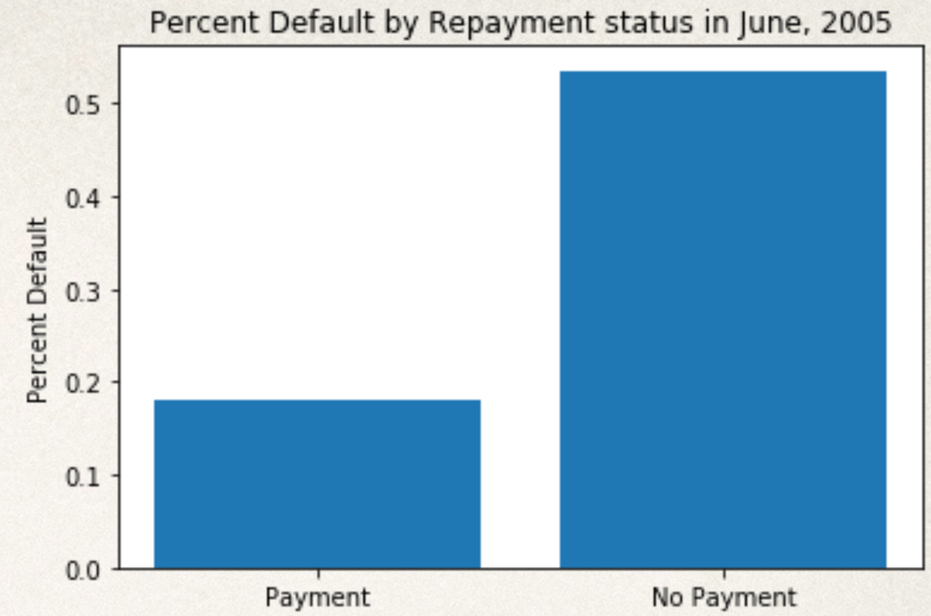


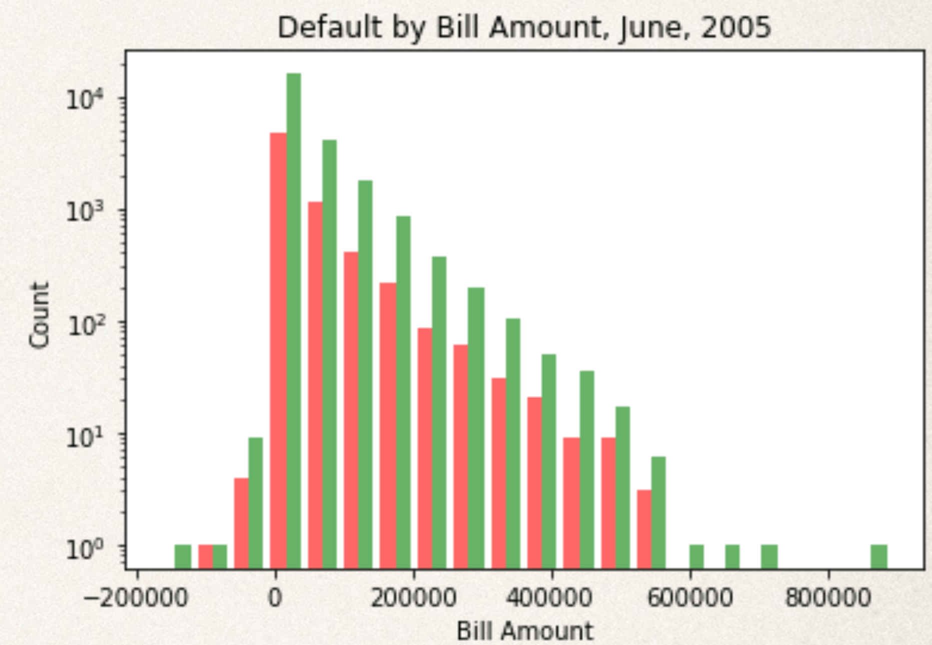


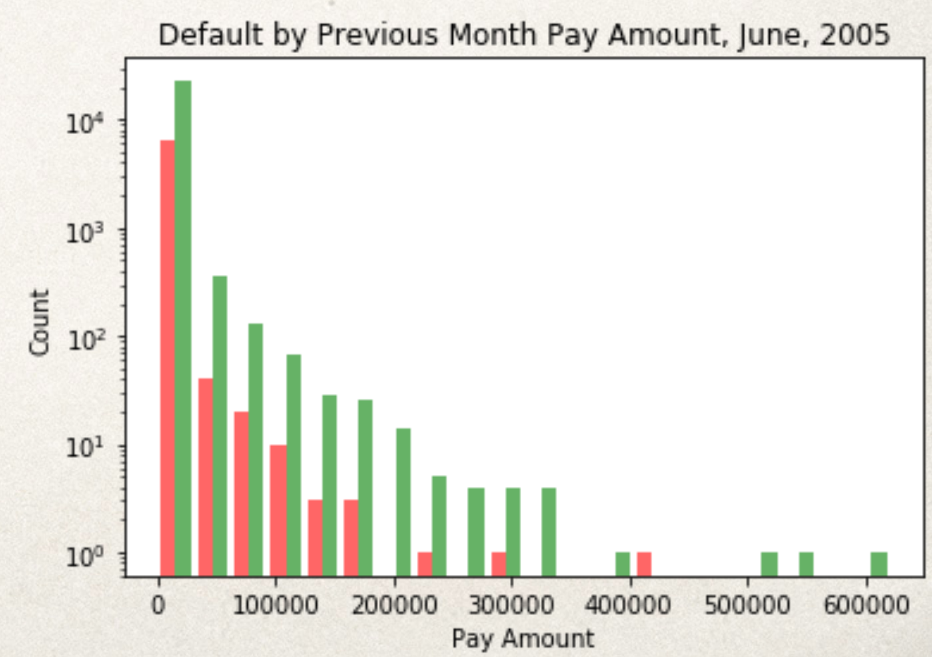


Pay Data June, 2005

- 17.95% of paying clients defaulted
- Clients with bill amount 0 or less defaulted (?)
- Negative correlation between pay amount and default
- T-test results (bill amount):
  -Test statistic 1.75
  -P-value 0.079
- T-test results (pay amount):
  -Test statistic 9.85
  -P-value 6.83e^{-23}

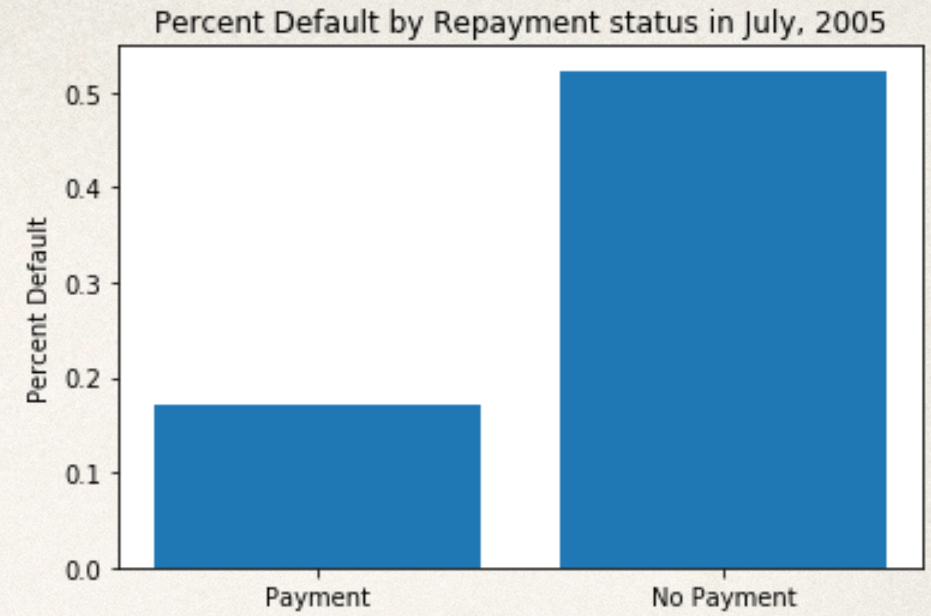


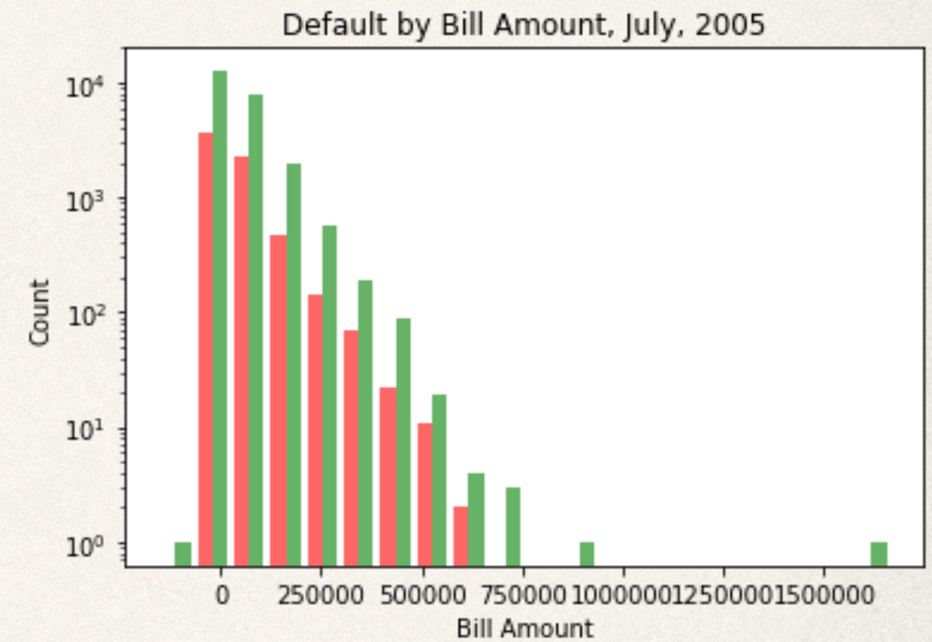


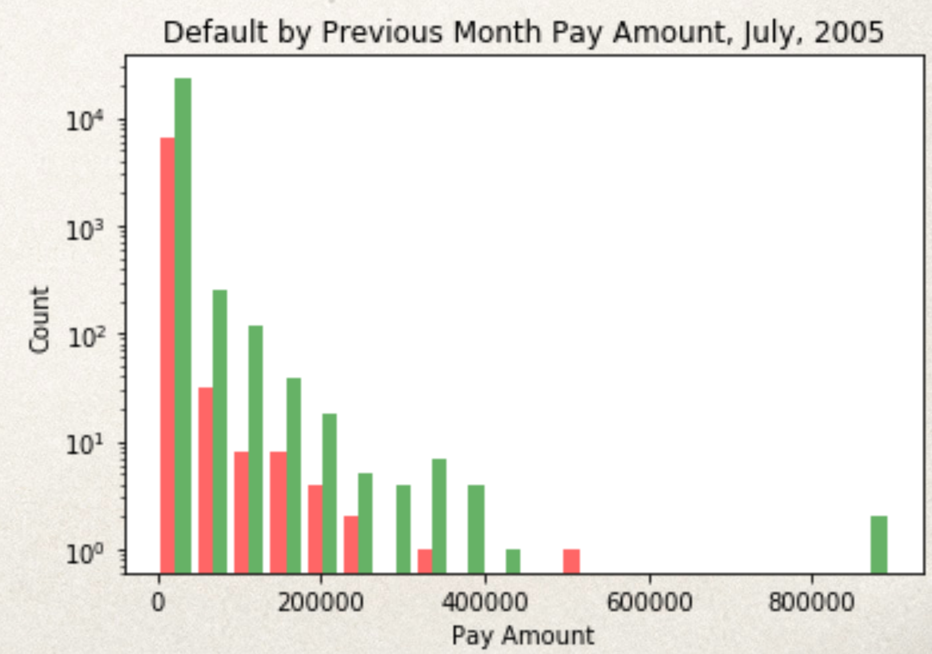


Pay Data July, 2005

- 17.19% of paying clients defaulted
- Clients with bill amount 0 or less defaulted (?)
- Negative correlation between pay amount and default
- T-test results (bill amount):
  -Test statistic 2.43
  -P-value 0.015
- T-test results (pay amount):
  -Test statistic 9.75
  -P-value $1.84e^{-22}$

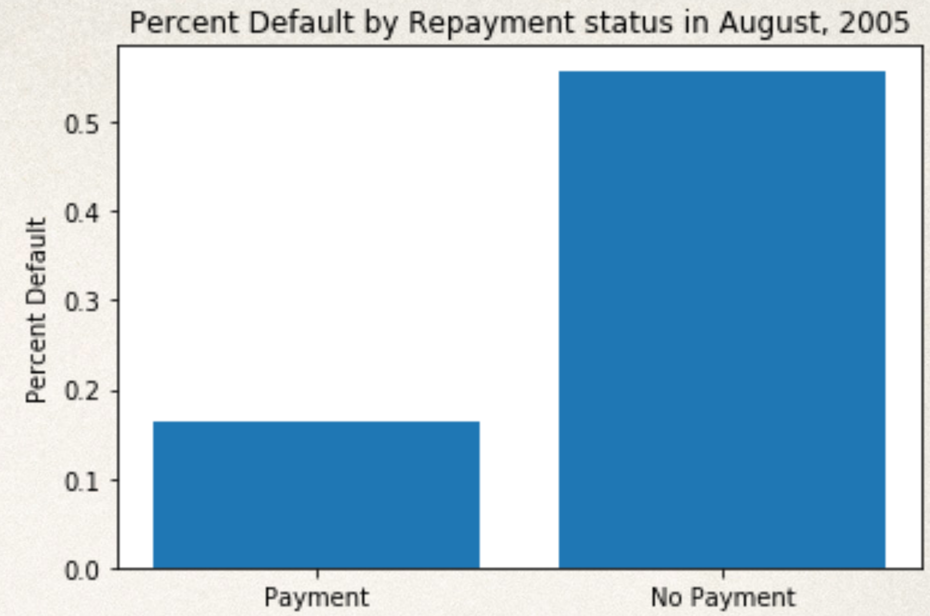


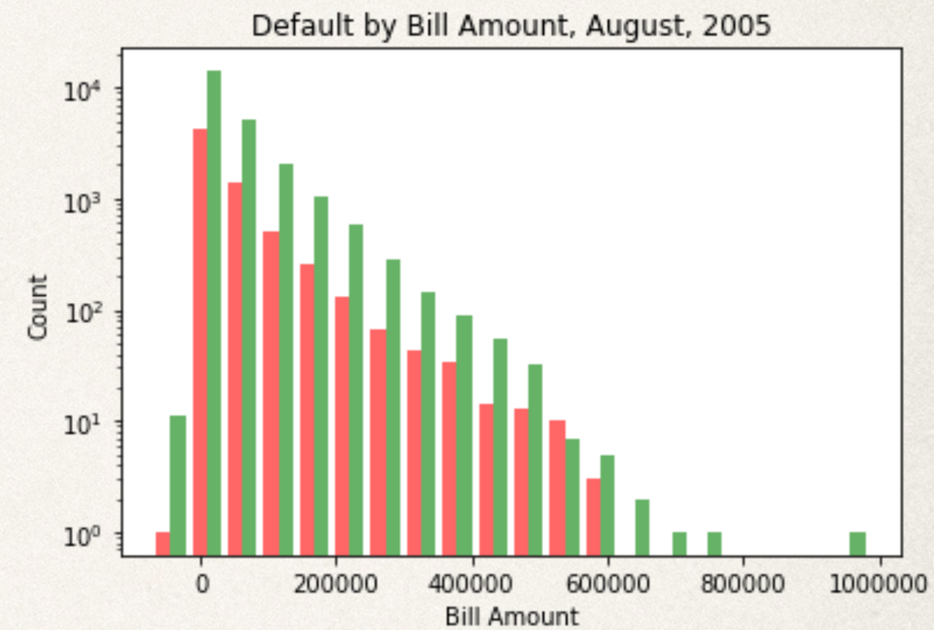


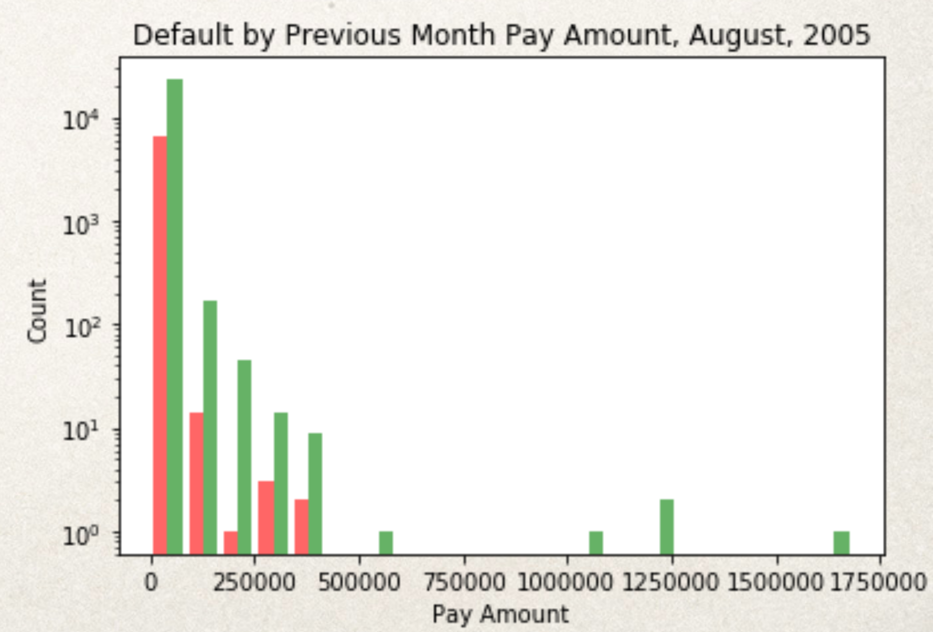


Pay Data August, 2005

- 16.27% of paying clients defaulted
- Clients with bill amount 0 or less defaulted (?)
- Negative correlation between pay amount and default
- T-test results (bill amount):
  -Test statistic 2.46
  -P-value 0.014
- T-test results (pay amount):
  -Test statistic 10.16
  -P-value $3.17e^{-24}$

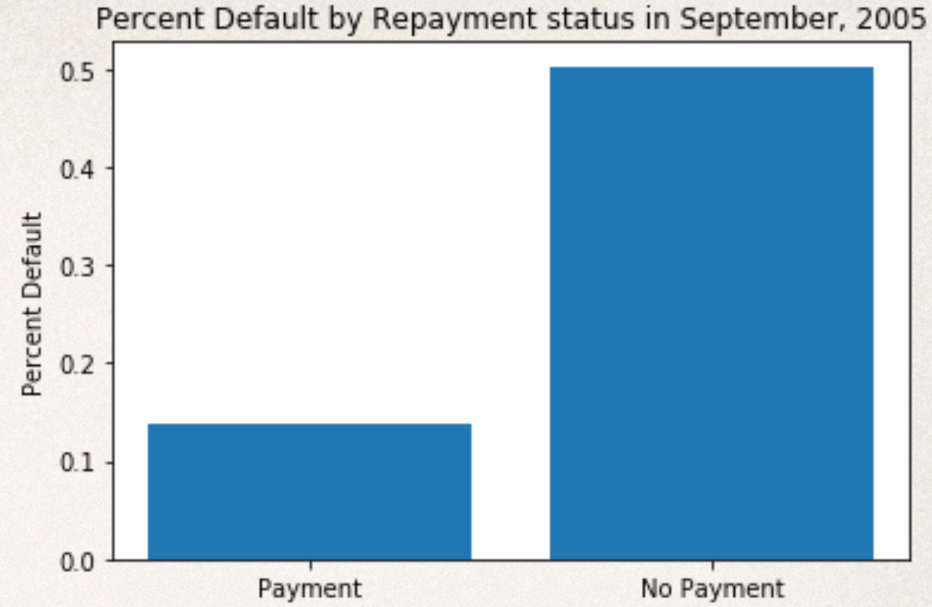


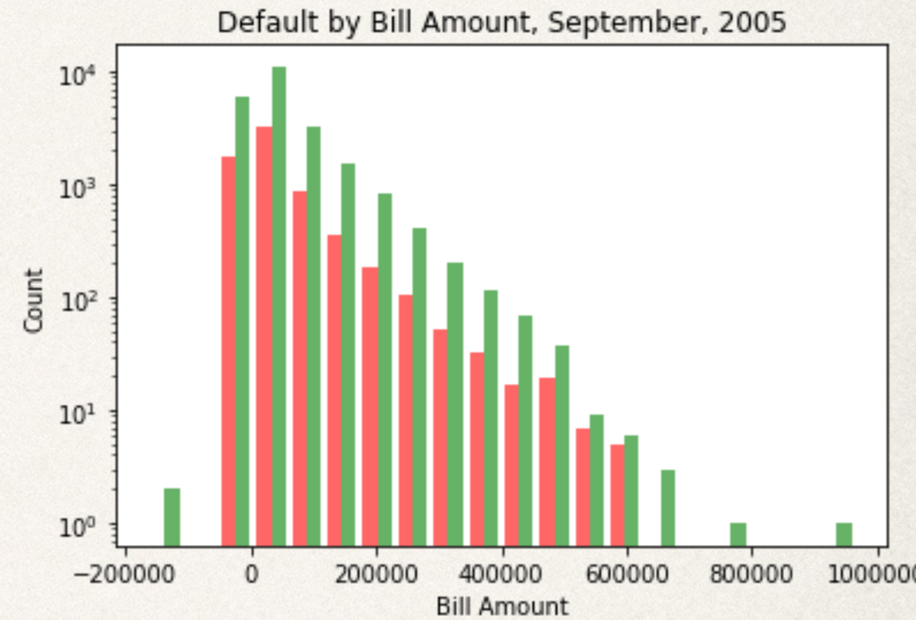


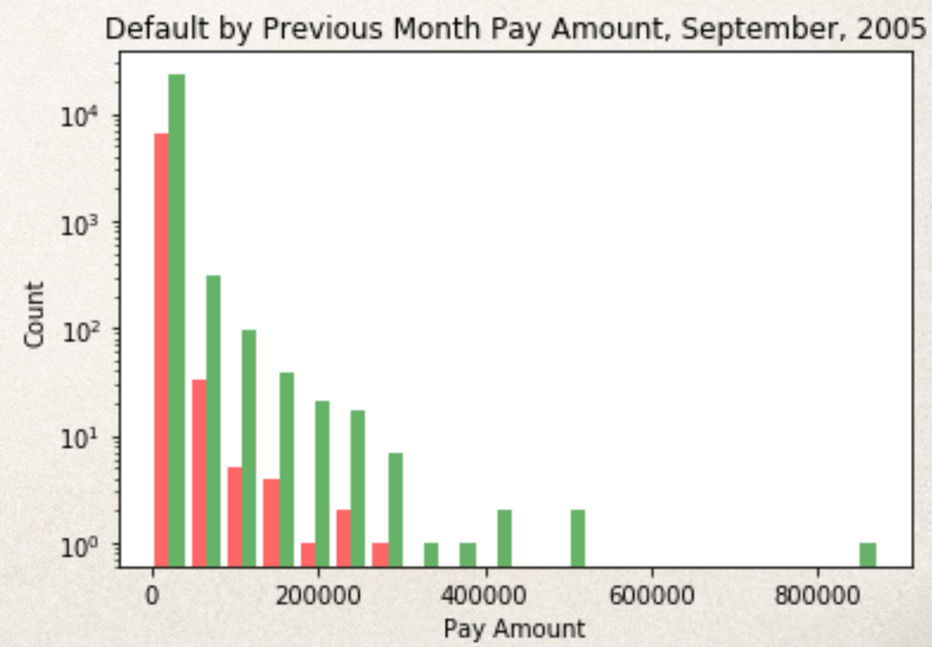


Pay Data September, 2005

- 13.83% of paying clients defaulted
- Clients with bill amount 0 or less defaulted (?)
- Negative correlation between pay amount and default
- T-test results (bill amount):
  -Test statistic 3.40
  -P-value 0.001
- T-test results (pay amount):
  -Test statistic 12.66
  -P-value 1.15^{-36}







Data Modeling

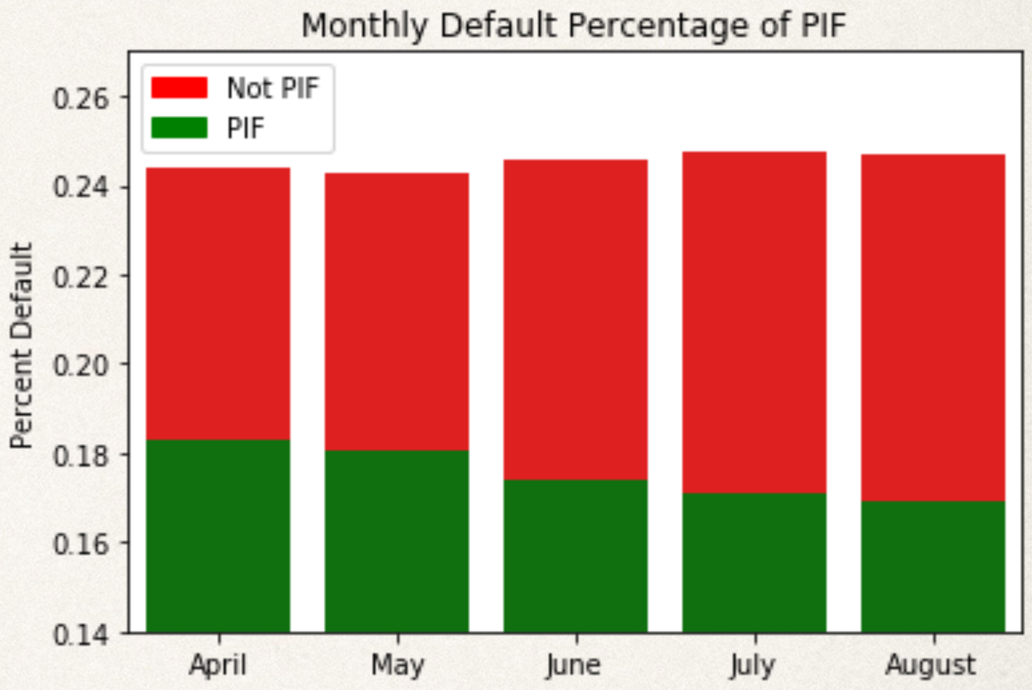
- Engineer ‘PIF’ feature
- Split categorical columns into dummy variables
- Feature selection
- Model selection
- Metric selection
- Model tuning

Engineering ‘PIF’

- PAY_AMT(N) >= BILL_AMT(N - 1)
  - August to April

EDA for PIF Columns

- 16.92% of clients who paid their August bill in full defaulted
- Negative balances
- Closed accounts labeled as default?



Feature Selection

- Drop clients who closed their accounts
  - *PIF8 = True & default = True*
- Exclude bill amount, pay amount columns
  - Described by ‘PIF’

Split categorical columns

- Marriage, Education
- Pandas *get_dummies*

Model Selection

- SciKit Learn
  - Decision Tree
  - Support Vector Machine
  - Random Forest
  - AdaBoost

Metric Selection

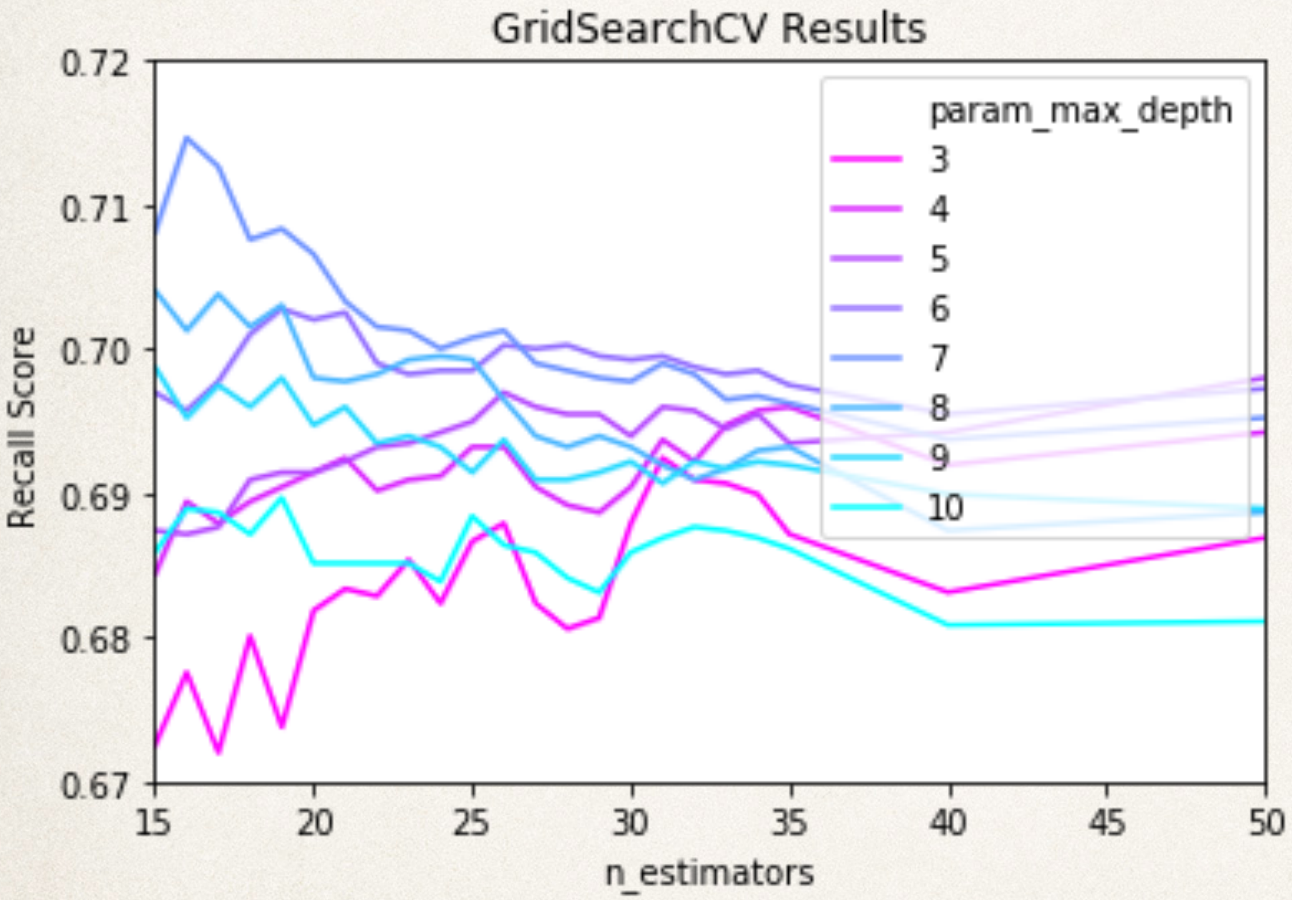
Goal: save the bank money

- Accuracy: *(TP + TN) / (FP + FN)*
- Precision: *TP / (TP + FP)*
- Recall: *TP / (TP + FN)*
- F1: 2 * *(precision * recall) / (precision + recall)*

Model Tuning

- SciKit Learn *GridSearchCV*
- Maximize recall score
- max_depth & n_estimators

Model Tuning



	feature	score
14	PIF_8	0.273711
8	PAY_9	0.225856
9	PAY_8	0.108314
10	PAY_7	0.076283
11	PAY_6	0.067449
0	LIMIT_BAL	0.055806
12	PAY_5	0.045125
15	PIF_7	0.044115
17	PIF_5	0.028379
13	PAY_4	0.025130
16	PIF_6	0.021164
18	PIF_4	0.009774
7	AGE	0.006657
2	GRADUATE_SCHOOL	0.003303
1	SEX	0.002296
3	UNIVERSITY	0.001859
6	SINGLE	0.001832
5	MARRIED	0.001518
4	HIGH_SCHOOL	0.001428

Model Results

Confusion Matrix		
	Predicted No Default	Predicted Default
No Default	3973	709
Default	275	705

Recall Score: 0.7194

Analysis Results

- Payment features best indicator of default
- Demographic features not as clear
  - Married clients are more likely to default than single
  - Males more likely to default than females
  - Default is highest for customers age 20-25

Further Research

- Dive deeper into false negatives data
- Try using only demographic data
- Test different models