Small Business Loan Exploratory Data Analysis

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Data Overview

The original dataset is from U.S. Small Business Administration (SBA), a governmental agency founded in 1953 to provide financial assistance to small enterprises in the U.S. credit market. The file contains 899,164 loan records from small businesses across the country and 27 variables. A detailed description of all variables can be found in Table 1. For the project, our primary research interests can be summarized into the following questions:

1. How does the requested loan duration (***Term***), revolving line of credit (***RevLineCr***), and employee count (***NoEmp***) of a small business impact the amount of the approved SBA loan (***GrAppv***)?
2. What are the different factors that impact the defaulting of a loan?

In addition, there are complexities in the original dataset to be aware of:

- Missing Values. Given the size of the dataset, it is not uncommon to find missing values on some variables. Table 2 shows the count of missing values for all variables in the original file. For the scope of the current project, we will exclude loan records with missing values except for the variable, ***ChgOffDate***, which indicates a date when a loan is declared to be in default. Given the rigorous review procedure that banks have set in place, only a small portion of loans are expected to default. Therefore, loans in good standing or have been paid off won't indicate a date when the loan is declared to be in default (***ChgOffDate***).

- Inconsistent Data Format. The following categorical variables contain values other than yes and no. Without further clarification from the original dataset, we will exclude loan records beyond the binary choices.

    - Revolving Line of Credit (***RevLineCr***)
    - Business Status: New or Existing Businesses (***NewExist***)
    - Business Locale: Rural or Urban (***UrbanRural***)
    - LowDoc Loan Program (***LowDoc***)
- Incorrect Data Type. The following variables that contain monetary values are represented as strings rather than numeric numbers in the original file. These variables will be converted to the numeric data type for our analysis.

    - SBA's Guaranteed Amount of Approved Loan (***SBA_Appv***)
    - Gross Amount of Loan Approved by Bank (***GrAppv***)
    - Charged-off Amount (***ChgOffPrinGr***)
    - Gross Amount Outstanding (***BalanceGross***)
    - Amount Disbursed (***DisbursementGross***)
- Data Distribution. For the following variables, the distribution is not normal but instead skewed to either the left or the right. In addition, there are also significant outliers which need to be handled by either transformations or exclusions from the dataset prior to modelling. Categorical variables have factor imbalances i.e. more occurence of one factor as compared to the others.

    - Gross Amount of Loan Approved by Bank (***GrAppv***)

- Number of Business Employees (***NoEmp***)
- Urban/Rural Columns (***UrbanRurac_fac***)

Primary Relationship of Interest

For the first research question, we first look at the distribution of the response variable ***GrAppv_num*** From the histogram and the density plot (Figure1),the response variable doesn't look normal.After transforming the variable by applying natural log, the distribution of the ***GrAppv_num*** looks normal now. We then explore the relationship between ***GrAppv_num*** and each predictor. Using scatter plots for continuous/numeric predictors while apply boxplots for categorical predictors (Figure2 and Figure3 in the Appendix). From the plots, it is worth mentioning that the relationship between the response variable and predictors ***Term*** and ***NoEmp*** seem not linear. There are also some difference in mean for the gross amount of loan approved by bank vs revolving line of credit which shows the relation between ***GrAppv_num*** and ***RevLineCr_fac*** is worth considering.

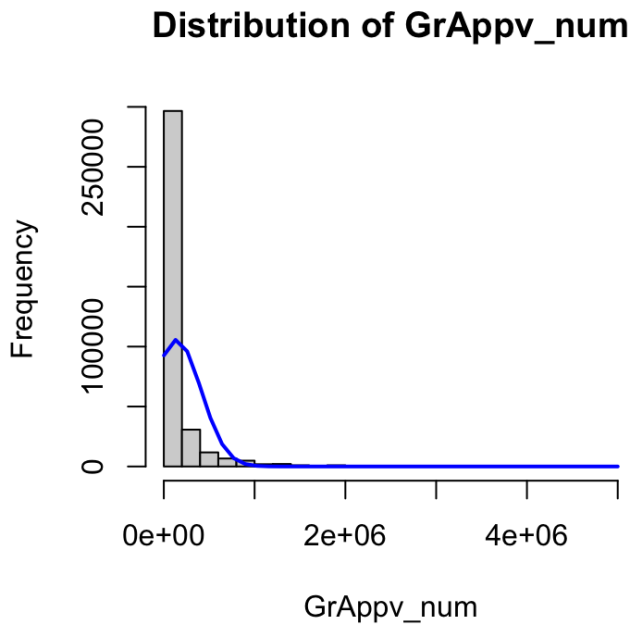
For the second research question, Tables 4 through 7 and Figure 4 in the Appendix present the descriptive statistics. The key findings include:

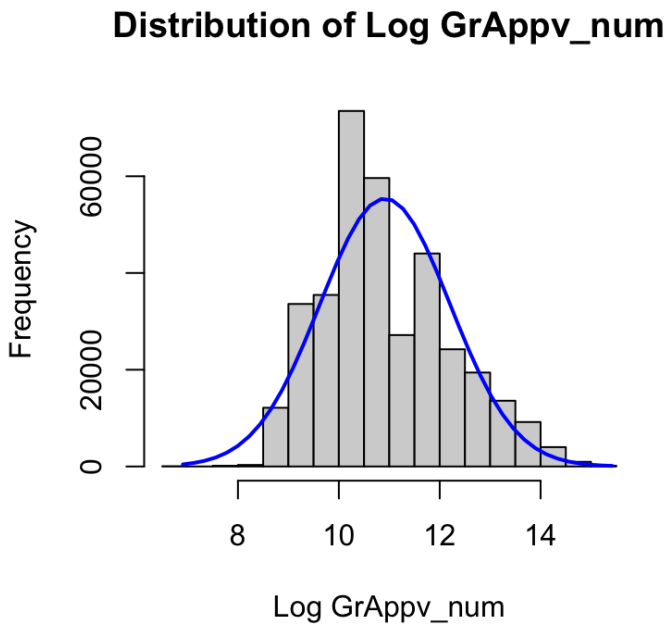
- Majority of the establishments applying for the small business loans are existing businesses that operate in urban settings.
- The default rate varies between states.California, New York, and Florida have the highest percentage of small businesses defaulting on their loans.
- 77% of small business loans in default occurred between the time period of 2005 and 2008, but this is likely due to the fact that about 76% of loans were distributed around the same time period.

Summary Statistics

Variable	N	Mean	Std. Dev.	Min	Pctl. 25	Pctl. 75	Max
Term	357597	82.828	59.081	0	50	84	527
RevLineCr_fac	357597						
… N	167293	46.8%					
… Y	190304	53.2%					
NoEmp	357597	8.344	31.757	0	2	8	8000
GrAppv_num	357597	139403.767	269915.621	1000	25000	120000	5e+06

Figure 1.Distribution of Gross Amount of Loan Approved by Bank





Other Characteristics

For the first research question:

- From the summary statistics, it can be observed that ***NoEmp*** is right-skewed.
- The majority of the loan term in months is shorter than 100 months.
- The proportion of whether the loan is approve or not, depends almost equally (46.8% v.s. 53.2%) on whether the business has a revolving line of credit.

For the second research question:

- From Table 4, we can observe that small businesses that create less amount of jobs generally have higher potential to default.
- Likewise, the more jobs retained by the company, the less likely the business will default.
- Almost all of the small business in this analysis are not involved in the LowDoc Loan Program.

Potential Challenges

The following are the challenges identified when performing EDA on the dataset.

1. The first challenge is the exclusion of loan records values beyond the binary (Y/N) choices that were showing up within the variable. The reason for that was there was lack of information about what the different values represent. And so by applying restrictions to only include Y/N values, there is a potential loss of information.
2. The second challenge is that there are variables that are in line with the outcome variable, balance gross, MIS status and charge off amount. These variables have to excluded from the analysis as they are all bi-variate outcomes.
3. The data was too large causing inefficiency.
4. Due to the data not being as clean as it should have been, it kind of resulted it to becoming deleted. If we had found an easier way rather than removing, the data would have been more consistent.

Appendix

Code Book

Variable	Description
LoanNr_ChkDgt	Identifier Primary Key
Name	Borrower Name
City	Borrower City
State	Borrower State
Zip	Borrower Zip Code
Bank	Bank Name
BankState	Bank State
NAICS	North American Industry Classification System Code
ApprovalDate	Date SBA Commitment Issued
ApprovalFY	Fiscal Year of Commitment
Term	Loan Term in Months
NoEmp	Number of Business Employees
NewExist	1 = Existing Business, 2 = New Business, 0 = Undefined
CreateJob	Number of Jobs Created
RetainedJob	Number of Jobs Retained
FranchiseCode	Franchise Code, (00000 or 00001) = No Franchise
UrbanRural	1 = Urban, 2 = Rural, 0 = Undefined
RevLineCr	Revolving Line of Credit: Y = Yes, N = No
LowDoc	LowDoc Loan Program: Y = Yes, N = No
ChgOffDate	The date when a loan is declared to be in default
DisbursementDate	Disbursement Date
DisbursementGross	Amount Disbursed

Variable	Description
BalanceGross	Gross Amount Outstanding
MIS_Status	Loan Status Charged off = CHGOFF, Paid in Full =PIF
ChgOffPrinGr	Charged-off Amount
GrAppv	Gross Amount of Loan Approved by Bank
SBA_Appv	SBA's Guaranteed Amount of Approved Loan

Missing Value Overview

Variable	Count of Missing Values
LoanNr_ChkDgt	0
Name	8
City	30
State	14
Zip	0
Bank	1559
BankState	1566
NAICS	0
ApprovalDate	0
ApprovalFY	0
Term	0
NoEmp	0
NewExist	136
CreateJob	0
RetainedJob	0
FranchiseCode	0
UrbanRural	0

Variable	Count of Missing Values
RevLineCr	4528
LowDoc	2582
ChgOffDate	736465
DisbursementDate	2368
DisbursementGross	0
BalanceGross	0
MIS_Status	1997
ChgOffPrinGr	0
GrAppv	0
SBA_Appv	0

Figure 2.Scatter Plot of Gross Amount of Loan Approved by Bank and Loan term in months/Number of business employees

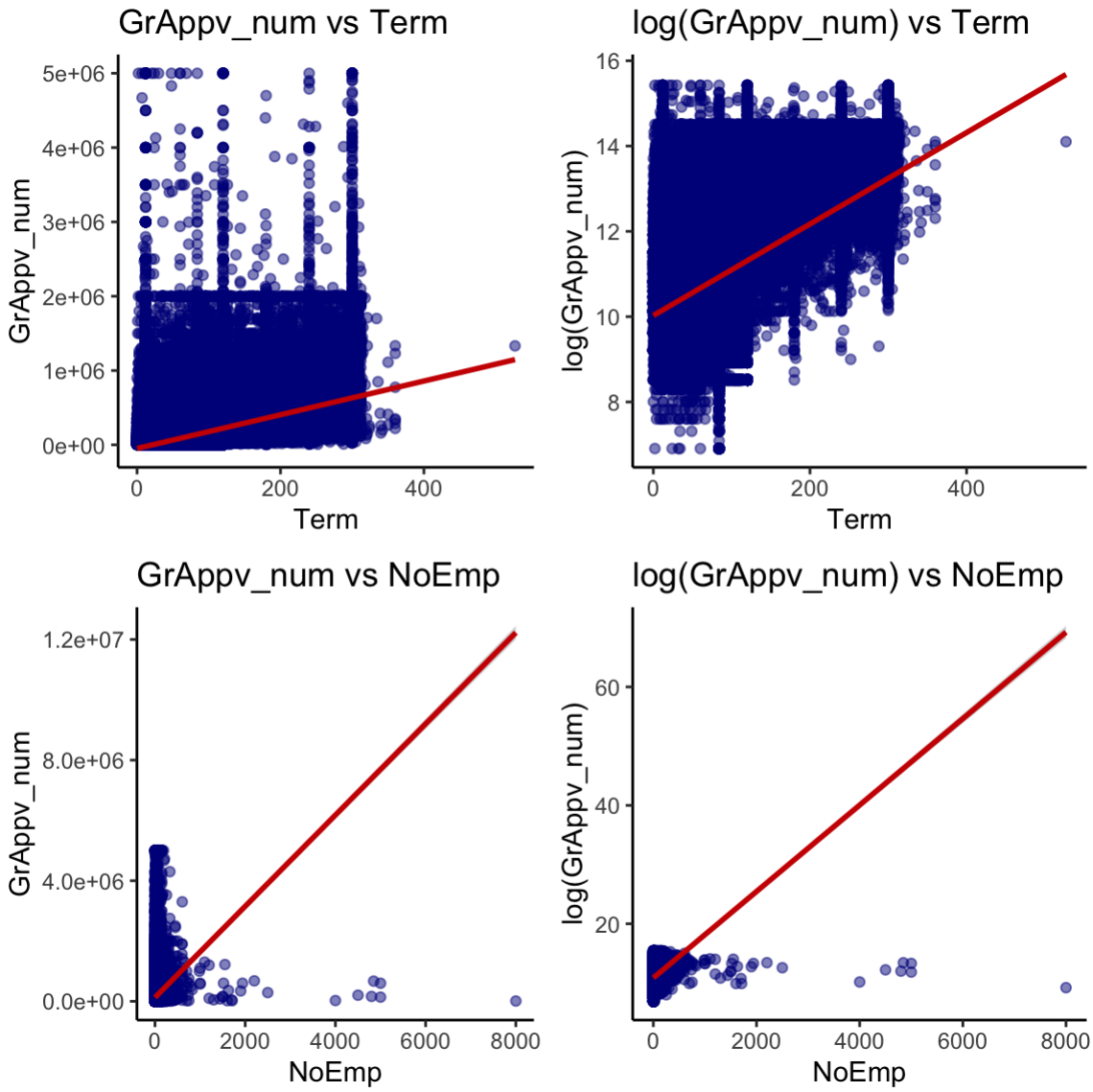


Figure 3.Comparison of Revolving Line of Credit in the Gross Amount of Loan Approved by Bank

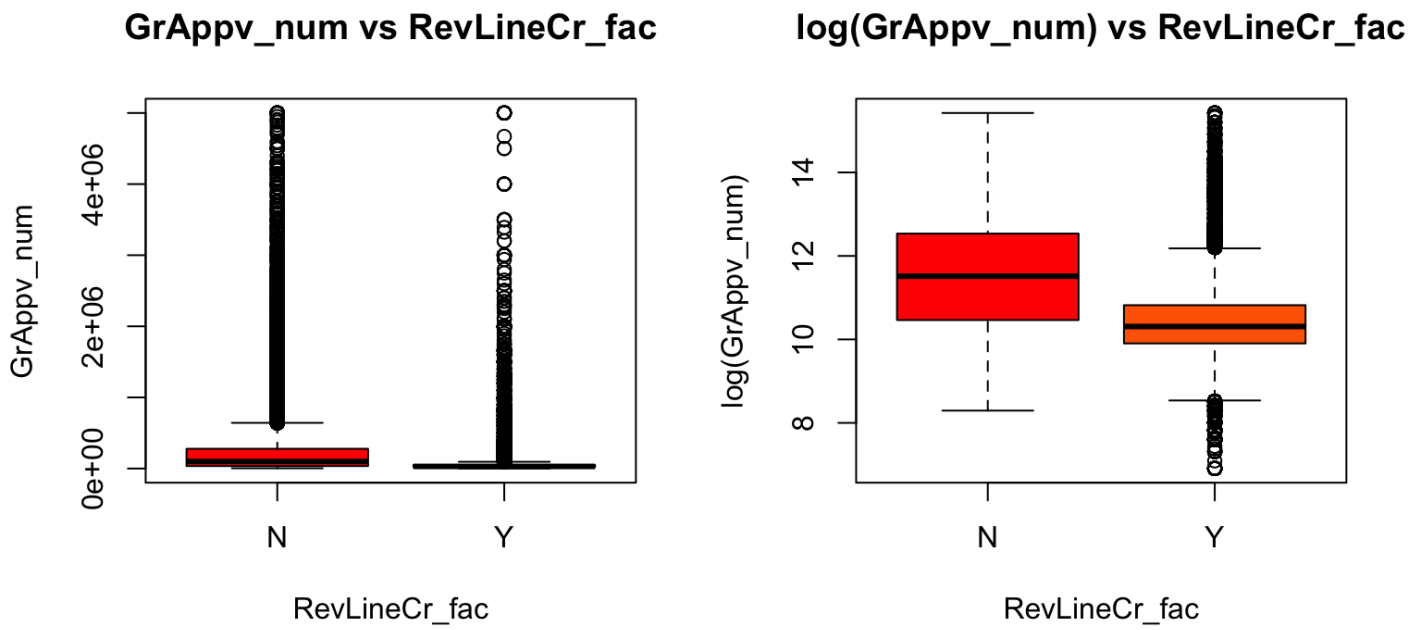


Table 4.Descriptive of Small Business Loans by Loan Status (I)

	CHGOFF (N=94522)	P I F (N=263075)	Overall (N=357597)
Term			
Mean (SD)	48.4 (34.3)	95.2 (61.2)	82.8 (59.1)
Median [Min, Max]	46.0 [0, 339]	84.0 [0, 527]	84.0 [0, 527]
NoEmp			
Mean (SD)	5.81 (35.8)	9.25 (30.1)	8.34 (31.8)
Median [Min, Max]	3.00 [0, 8000]	4.00 [0, 5000]	3.00 [0, 8000]
NewExist_fac			
Existing Business	69692 (73.7%)	191552 (72.8%)	261244 (73.1%)
New Business	24830 (26.3%)	71523 (27.2%)	96353 (26.9%)
CreateJob			
Mean (SD)	1.73 (13.3)	2.14 (14.7)	2.03 (14.3)
Median [Min, Max]	0 [0, 1620]	0 [0, 5090]	0 [0, 5090]
RetainedJob			
Mean (SD)	4.80 (16.8)	5.99 (21.2)	5.68 (20.2)
Median [Min, Max]	3.00 [0, 4440]	2.00 [0, 7250]	2.00 [0, 7250]
UrbanRural_fac			
Urban	81242 (86.0%)	211441 (80.4%)	292683 (81.8%)
Rural	13280 (14.0%)	51634 (19.6%)	64914 (18.2%)
RevLineCr			
N	44385 (47.0%)	122908 (46.7%)	167293 (46.8%)
Y	50137 (53.0%)	140167 (53.3%)	190304 (53.2%)
LowDoc			
N	94294 (99.8%)	261742 (99.5%)	356036 (99.6%)
Y	228 (0.2%)	1333 (0.5%)	1561 (0.4%)
SBA_Appv_num			
Mean (SD)	52200 (123000)	120000 (245000)	102000 (222000)
Median [Min, Max]	20000 [500, 3410000]	25000 [500, 4500000]	25000 [500, 4500000]
GrAppv_num			
Mean (SD)	80400 (165000)	161000 (296000)	139000 (270000)
Median [Min, Max]	35000 [1000, 3500000]	50000 [1000, 5000000]	50000 [1000, 5000000]
ChgOffPrinGr_num			
Mean (SD)	58000 (113000)	162 (3030)	15500 (63300)
Median [Min, Max]	28100 [0, 2220000]	0 [0, 634000]	0 [0, 2220000]
BalanceGross_num			
Mean (SD)	0 (0)	7.66 (2530)	5.63 (2170)
Median [Min, Max]	0 [0, 0]	0 [0, 996000]	0 [0, 996000]

	CHGOFF (N=94522)	P I F (N=263075)	Overall (N=357597)
DisbursementGross_num			
Mean (SD)	102000 (171000)	184000 (315000)	163000 (286000)
Median [Min, Max]	50000 [4000, 4360000]	72900 [4000, 11400000]	63900 [4000, 11400000]

Table 5.Descriptive of Small Business Loans by Loan Status (II)

	CHGOFF (N=94522)	P I F (N=263075)	Overall (N=357597)
State			
AK	73 (0.1%)	425 (0.2%)	498 (0.1%)
AL	723 (0.8%)	1619 (0.6%)	2342 (0.7%)
AR	454 (0.5%)	1385 (0.5%)	1839 (0.5%)
AZ	2471 (2.6%)	4375 (1.7%)	6846 (1.9%)
CA	15935 (16.9%)	32327 (12.3%)	48262 (13.5%)
CO	2315 (2.4%)	5466 (2.1%)	7781 (2.2%)
CT	1044 (1.1%)	4683 (1.8%)	5727 (1.6%)
DC	156 (0.2%)	495 (0.2%)	651 (0.2%)
DE	243 (0.3%)	661 (0.3%)	904 (0.3%)
FL	7465 (7.9%)	12696 (4.8%)	20161 (5.6%)
GA	3039 (3.2%)	4947 (1.9%)	7986 (2.2%)
HI	251 (0.3%)	923 (0.4%)	1174 (0.3%)
IA	474 (0.5%)	2341 (0.9%)	2815 (0.8%)
ID	855 (0.9%)	3061 (1.2%)	3916 (1.1%)
IL	4346 (4.6%)	9193 (3.5%)	13539 (3.8%)
IN	1504 (1.6%)	5033 (1.9%)	6537 (1.8%)
KS	528 (0.6%)	2331 (0.9%)	2859 (0.8%)
KY	728 (0.8%)	2351 (0.9%)	3079 (0.9%)
LA	713 (0.8%)	1957 (0.7%)	2670 (0.7%)
MA	2260 (2.4%)	10392 (4.0%)	12652 (3.5%)
MD	1402 (1.5%)	4084 (1.6%)	5486 (1.5%)
ME	316 (0.3%)	2001 (0.8%)	2317 (0.6%)
MI	3287 (3.5%)	7148 (2.7%)	10435 (2.9%)
MN	1651 (1.7%)	7205 (2.7%)	8856 (2.5%)
MO	1491 (1.6%)	4910 (1.9%)	6401 (1.8%)
MS	629 (0.7%)	2487 (0.9%)	3116 (0.9%)
MT	224 (0.2%)	2081 (0.8%)	2305 (0.6%)
NC	1397 (1.5%)	4051 (1.5%)	5448 (1.5%)
ND	124 (0.1%)	1384 (0.5%)	1508 (0.4%)
NE	270 (0.3%)	1460 (0.6%)	1730 (0.5%)
NH	902 (1.0%)	4771 (1.8%)	5673 (1.6%)
NJ	3178 (3.4%)	7322 (2.8%)	10500 (2.9%)
NM	282 (0.3%)	1461 (0.6%)	1743 (0.5%)
NV	1226 (1.3%)	1995 (0.8%)	3221 (0.9%)
NY	8018 (8.5%)	20665 (7.9%)	28683 (8.0%)

	CHGOFF (N=94522)	P I F (N=263075)	Overall (N=357597)
OH	3573 (3.8%)	11986 (4.6%)	15559 (4.4%)
OK	711 (0.8%)	2588 (1.0%)	3299 (0.9%)
OR	1143 (1.2%)	3756 (1.4%)	4899 (1.4%)
PA	3078 (3.3%)	12898 (4.9%)	15976 (4.5%)
RI	715 (0.8%)	3619 (1.4%)	4334 (1.2%)
SC	582 (0.6%)	1528 (0.6%)	2110 (0.6%)
SD	123 (0.1%)	867 (0.3%)	990 (0.3%)
TN	945 (1.0%)	2396 (0.9%)	3341 (0.9%)
TX	5848 (6.2%)	16266 (6.2%)	22114 (6.2%)
UT	2602 (2.8%)	7511 (2.9%)	10113 (2.8%)
VA	1361 (1.4%)	3990 (1.5%)	5351 (1.5%)
VT	172 (0.2%)	1365 (0.5%)	1537 (0.4%)
WA	2057 (2.2%)	6776 (2.6%)	8833 (2.5%)
WI	1408 (1.5%)	6489 (2.5%)	7897 (2.2%)
WV	170 (0.2%)	750 (0.3%)	920 (0.3%)
WY	60 (0.1%)	604 (0.2%)	664 (0.2%)

Figure 4.Default Rate of Loan by States in Continental US

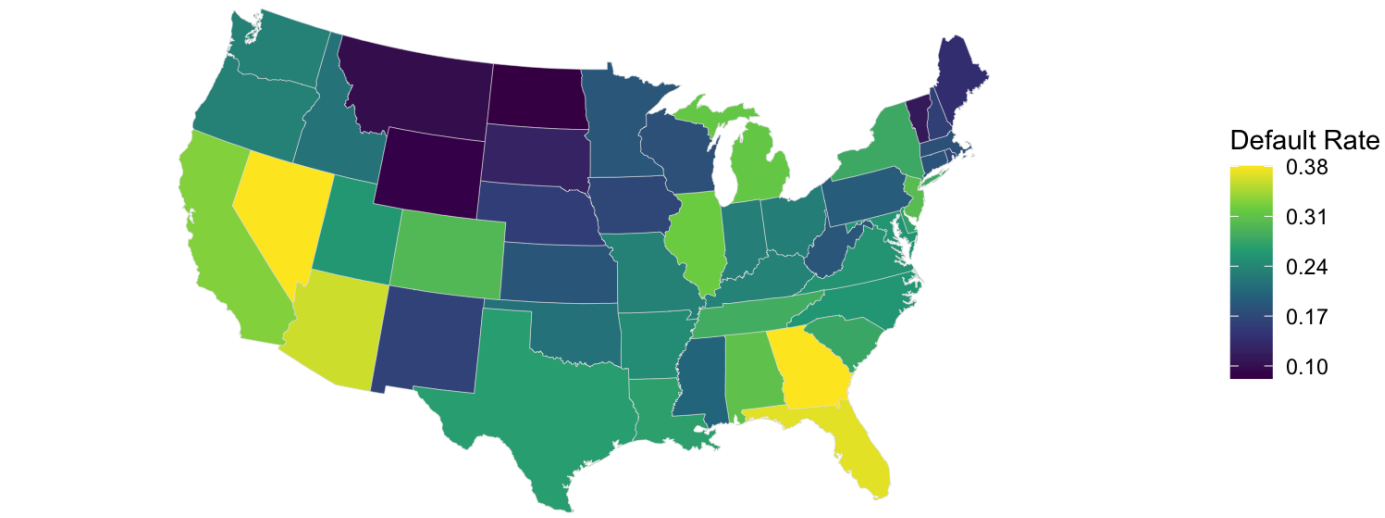


Table 6.Descriptive of Small Business Loans by Loan Status (III)

	CHGOFF (N=94522)	P I F (N=263075)	Overall (N=357597)
ApprovalFY			
1994	2 (0.0%)	60 (0.0%)	62 (0.0%)
1995	11 (0.0%)	268 (0.1%)	279 (0.1%)
1996	8 (0.0%)	79 (0.0%)	87 (0.0%)
1997	21 (0.0%)	336 (0.1%)	357 (0.1%)
1998	32 (0.0%)	160 (0.1%)	192 (0.1%)
1999	507 (0.5%)	5208 (2.0%)	5715 (1.6%)
2000	1495 (1.6%)	13099 (5.0%)	14594 (4.1%)
2001	1718 (1.8%)	13658 (5.2%)	15376 (4.3%)
2002	2204 (2.3%)	16581 (6.3%)	18785 (5.3%)
2003	3670 (3.9%)	24272 (9.2%)	27942 (7.8%)
2004	5347 (5.7%)	27620 (10.5%)	32967 (9.2%)
2005	12723 (13.5%)	34614 (13.2%)	47337 (13.2%)
2006	20220 (21.4%)	35425 (13.5%)	55645 (15.6%)
2007	26293 (27.8%)	30691 (11.7%)	56984 (15.9%)
2008	13726 (14.5%)	15760 (6.0%)	29486 (8.2%)
2009	3269 (3.5%)	13103 (5.0%)	16372 (4.6%)
2010	2039 (2.2%)	13691 (5.2%)	15730 (4.4%)
2011	866 (0.9%)	10740 (4.1%)	11606 (3.2%)
2012	301 (0.3%)	5169 (2.0%)	5470 (1.5%)
2013	65 (0.1%)	2282 (0.9%)	2347 (0.7%)
2014	5 (0.0%)	259 (0.1%)	264 (0.1%)

Table 7.Descriptive of Small Business Loans by Loan Status (IV)

	CHGOFF (N=94522)	P I F (N=263075)	Overall (N=357597)
factor(Disbursement_Year)			
1994	2 (0.0%)	58 (0.0%)	60 (0.0%)
1995	11 (0.0%)	248 (0.1%)	259 (0.1%)
1996	8 (0.0%)	80 (0.0%)	88 (0.0%)
1997	20 (0.0%)	321 (0.1%)	341 (0.1%)
1998	29 (0.0%)	188 (0.1%)	217 (0.1%)
1999	553 (0.6%)	4348 (1.7%)	4901 (1.4%)
2000	1533 (1.6%)	12270 (4.7%)	13803 (3.9%)
2001	1684 (1.8%)	13074 (5.0%)	14758 (4.1%)
2002	2374 (2.5%)	16764 (6.4%)	19138 (5.4%)
2003	3871 (4.1%)	23659 (9.0%)	27530 (7.7%)
2004	6231 (6.6%)	29036 (11.0%)	35267 (9.9%)
2005	13423 (14.2%)	34558 (13.1%)	47981 (13.4%)
2006	22050 (23.3%)	36973 (14.1%)	59023 (16.5%)
2007	25964 (27.5%)	28767 (10.9%)	54731 (15.3%)
2008	10483 (11.1%)	16443 (6.3%)	26926 (7.5%)
2009	3457 (3.7%)	15048 (5.7%)	18505 (5.2%)
2010	1759 (1.9%)	13874 (5.3%)	15633 (4.4%)
2011	730 (0.8%)	9954 (3.8%)	10684 (3.0%)
2012	267 (0.3%)	5025 (1.9%)	5292 (1.5%)
2013	68 (0.1%)	2161 (0.8%)	2229 (0.6%)
2014	5 (0.0%)	224 (0.1%)	229 (0.1%)
2020	0 (0%)	1 (0.0%)	1 (0.0%)
2028	0 (0%)	1 (0.0%)	1 (0.0%)

```
knitr::opts_chunk$set(echo = FALSE)
#Clear environment and load libraries
rm(list = ls())
library(ISLR2)
library(kableExtra)
library(stargazer)
library(ggplot2)
library(caret)
library(dplyr)
library(leaps)
library(tidyverse)
library(table1)
library(Hmisc)
library(openintro)
library(lubridate)
library(vtable)
library(maps)
library(mapproj)
##Read into the original dataset
sbl <- read.csv('SBAnational.csv',header=T, na.strings=c("","  ","NA"))

##Remove blank row or rows of binary variables that contain values other than yes and no
sbl$NewExist[sbl$NewExist == 0] <- NA
sbl$UrbanRural[sbl$UrbanRural == 0] <- NA
sbl <- sbl[!is.na(sbl$RevLineCr) == TRUE ,]
sbl <- sbl[!is.na(sbl$NewExist) == TRUE ,]
sbl <- sbl[!is.na(sbl$UrbanRural) == TRUE ,]
sbl <- sbl[!is.na(sbl$Name) == TRUE ,]
sbl <- sbl[!is.na(sbl$City) == TRUE ,]
sbl <- sbl[!is.na(sbl$State) == TRUE ,]
sbl <- sbl[!is.na(sbl$Bank) == TRUE ,]
sbl <- sbl[!is.na(sbl$BankState) == TRUE ,]
sbl <- sbl[!is.na(sbl$LowDoc) == TRUE ,]
sbl <- sbl[!is.na(sbl$DisbursementDate) == TRUE ,]
sbl <- sbl[!is.na(sbl$DisbursementGross) == TRUE ,]
sbl <- sbl[!is.na(sbl$MIS_Status) == TRUE ,]
sbl <- subset(sbl, RevLineCr =="Y" | RevLineCr =="N")
sbl <- subset(sbl, LowDoc =="Y" | LowDoc =="N")

##Remove '$' sign and commas then convert to double in the money columns and store the values in
new columns
sbl$SBA_Appv_num <-str_replace_all(sbl$SBA_Appv,"[\\$,]","")%>% as.double()
sbl$GrAppv_num <-str_replace_all(sbl$GrAppv,"[\\$,]","") %>% as.double()
sbl$ChgOffPrinGr_num <-str_replace_all(sbl$ChgOffPrinGr,"[\\$,]","") %>% as.double()
sbl$BalanceGross_num <-str_replace_all(sbl$BalanceGross,"[\\$,]","") %>% as.double()
sbl$DisbursementGross_num <-str_replace_all(sbl$DisbursementGross,"[\\$,]","") %>% as.double()



## Extract the year of disbursement from Disbursement Date
sbl$Disbursement_Year <- year(as.Date(sbl$DisbursementDate,"%d-%b-%y"))

##Factor Categorical Variables listed as numeric
```

```
sbl$NewExist_fac <- factor(sbl$NewExist, levels = c("1","2"),
                        labels = c("Existing Business","New Business"))

sbl$UrbanRural_fac <- factor(sbl$UrbanRural, levels = c("1","2"),
                        labels = c("Urban","Rural"))

sbl$RevLineCr_fac <- as.factor(sbl$RevLineCr)
#types of variables
#str(sbl)
#Term  RevLineCr NoEmp
vars <- c("Term", "RevLineCr_fac", "NoEmp","GrAppv_num")
sbl_q1 <- sbl[vars]
#summary(sbl_q1)
st(sbl_q1)

cat(text="Figure 1.Distribution of Gross Amount of Loan Approved by Bank")
par(mfrow=c(1,2))
h1 <- hist(sbl_q1$GrAppv_num,xlab="GrAppv_num",main="Distribution of GrAppv_num")
xfit<-seq(min(sbl_q1$GrAppv_num),max(sbl_q1$GrAppv_num),length=40)
yfit<-dnorm(xfit,mean=mean(sbl_q1$GrAppv_num),sd=sd(sbl_q1$GrAppv_num))
yfit <- yfit*diff(h1$mids[1:2])*length(sbl_q1$GrAppv_num)
lines(xfit, yfit, col="blue", lwd=2)
#Since the distribution of `GrAppv_num` is not really normal, transform the variable by applying
natural log.

h2 <- hist(log(sbl_q1$GrAppv_num),xlab="Log GrAppv_num",main="Distribution of Log GrAppv_num")
xfit<-seq(min(log(sbl_q1$GrAppv_num)),max(log(sbl_q1$GrAppv_num)),length=40)
yfit<-dnorm(xfit,mean=mean(log(sbl_q1$GrAppv_num)),sd=sd(log(sbl_q1$GrAppv_num)))
yfit <- yfit*diff(h2$mids[1:2])*length(log(sbl_q1$GrAppv_num))
lines(xfit, yfit, col="blue", lwd=2)

#Code Book
data_dict <- matrix(
  c("LoanNr_ChkDgt","Name","City","State",
    "Zip", "Bank", "BankState","NAICS", "ApprovalDate",
    "ApprovalFY","Term","NoEmp","NewExist","CreateJob",
    "RetainedJob","FranchiseCode","UrbanRural","RevLineCr",
    "LowDoc","ChgOffDate","DisbursementDate","DisbursementGross",
    "BalanceGross","MIS_Status","ChgOffPrinGr","GrAppv","SBA_Appv",
    "Identifier Primary Key","Borrower Name","Borrower City",
    "Borrower State","Borrower Zip Code","Bank Name",
    "Bank State","North American Industry Classification System Code",
    "Date SBA Commitment Issued","Fiscal Year of Commitment",
    "Loan Term in Months","Number of Business Employees",
    "1 = Existing Business, 2 = New Business, 0 = Undefined","Number of Jobs Created",
    "Number of Jobs Retained","Franchise Code, (00000 or 00001) = No Franchise",
    "1 = Urban, 2 = Rural, 0 = Undefined",
    "Revolving Line of Credit: Y = Yes, N = No",
    "LowDoc Loan Program: Y = Yes, N = No",
    "The date when a loan is declared to be in default",
    "Disbursement Date","Amount Disbursed","Gross Amount Outstanding",
    "Loan Status Charged off = CHGOFF, Paid in Full =PIF",
```

```
    "Charged-off Amount","Gross Amount of Loan Approved by Bank",
    "SBA’s Guaranteed Amount of Approved Loan"),nrow=27,ncol=2)

kable(data_dict,
      col.names=c("Variable","Description"),
      format="html",
      booktabs=T,
      caption="Code Book") %>%
  kable_styling(position="center",latex_options = c("hold_position"))

#Missing Value Overview
MissingValues <- matrix(
  c("LoanNr_ChkDgt","Name","City","State",
    "Zip", "Bank", "BankState","NAICS", "ApprovalDate",
    "ApprovalFY","Term","NoEmp","NewExist","CreateJob",
    "RetainedJob","FranchiseCode","UrbanRural","RevLineCr",
    "LowDoc","ChgOffDate","DisbursementDate","DisbursementGross",
    "BalanceGross","MIS_Status","ChgOffPrinGr","GrAppv","SBA_Appv",
    "0","8","30","14","0","1559","1566","0","0","0","0","0","136",
    "0","0","0","0","4528","2582","736465","2368","0","0","1997",
    "0","0","0"),
  nrow=27,ncol=2)

kable(MissingValues,
      col.names=c("Variable","Count of Missing Values"),
      format="html",
      booktabs=T,
      caption="Missing Value Overview") %>%
  kable_styling(position="center",latex_options = c("hold_position"))

##EDA for Research Question #1
cat("\n\n\\pagebreak\n")
cat(text="Figure 2.Scatter Plot of Gross Amount of Loan Approved by Bank and Loan term in month
s/Number of business employees ")
#`GrAppv_num` and `Term`.
a <- ggplot(sbl_q1,aes(x=Term, y=GrAppv_num)) +
  geom_point(alpha = .5,colour="blue4") +
  geom_smooth(method="lm",col="red3") + theme_classic() +
  labs(title="GrAppv_num vs Term",x="Term",y="GrAppv_num")

#`log(GrAppv_num)` and `Term`.
b <- ggplot(sbl_q1,aes(x=Term, y=log(GrAppv_num))) +
  geom_point(alpha = .5,colour="blue4") +
  geom_smooth(method="lm",col="red3") + theme_classic() +
  labs(title="log(GrAppv_num) vs Term",x="Term",y="log(GrAppv_num)")

#`GrAppv_num` and `NoEmp`.
c <- ggplot(sbl_q1,aes(x=NoEmp, y=GrAppv_num)) +
  geom_point(alpha = .5,colour="blue4") +
  geom_smooth(method="lm",col="red3") + theme_classic() +
  labs(title="GrAppv_num vs NoEmp",x="NoEmp",y="GrAppv_num")
```

```
#`log(GrAppv_num)` and `NoEmp`.
d <- ggplot(sbl_q1,aes(x=NoEmp, y=log(GrAppv_num))) +
  geom_point(alpha = .5,colour="blue4") +
  geom_smooth(method="lm",col="red3") + theme_classic() +
  labs(title="log(GrAppv_num) vs NoEmp",x="NoEmp",y="log(GrAppv_num)")

library(grid)
grid.newpage()
pushViewport(viewport(layout = grid.layout(2, 2)))
vplayout <- function(x, y) viewport(layout.pos.row = x, layout.pos.col = y)
print(a, vp = vplayout(1, 1))  # key is to define vplayout
print(b, vp = vplayout(1, 2))
print(c, vp = vplayout(2, 1))
print(d, vp = vplayout(2, 2))
cat("\n\n\\pagebreak\n")
cat(text="Figure 3.Comparison of Revolving Line of Credit in the Gross Amount of Loan Approved b
y Bank")
par(mfrow=c(1,2))
#`GrAppv_num` and `RevLineCr_fac`.
e <- boxplot(GrAppv_num~RevLineCr_fac,data=sbl_q1, main="GrAppv_num vs RevLineCr_fac", ylab="GrA
ppv_num",xlab="RevLineCr_fac",col=rainbow(15))

#`log(GrAppv_num)` and `RevLineCr_fac`.
f <- boxplot(log(GrAppv_num)~RevLineCr_fac,data=sbl_q1, main="log(GrAppv_num) vs RevLineCr_fac",
ylab="log(GrAppv_num)",xlab="RevLineCr_fac",col=rainbow(15))

##EDA for Research Question #2
cat("\n\n\\pagebreak\n")
cat(text="Table 4.Descriptive of Small Business Loans by Loan Status (I)")
table1(~Term+NoEmp+NewExist_fac+CreateJob+
    RetainedJob+UrbanRural_fac+RevLineCr+LowDoc
    +SBA_Appv_num+GrAppv_num+ChgOffPrinGr_num+BalanceGross_num
    +DisbursementGross_num|MIS_Status,
       data=sbl)

cat("\n\n\\pagebreak\n")
cat(text="Table 5.Descriptive of Small Business Loans by Loan Status (II)")
table1(~State|MIS_Status,data=sbl)

cat("\n\n\\pagebreak\n")
cat(text="Figure 4.Default Rate of Loan by States in Continental US")
us_states <- map_data("state")
sbl_state <- sbl %>%
  mutate(State=tolower(abbr2state(State))) %>%
  group_by(State) %>%
  dplyr::summarize(Default_Rate = (sum((MIS_Status) == "CHGOFF")/ n()),na.rm=TRUE)

us_states %>%
  left_join(sbl_state, by=c("region"="State")) %>%
  ggplot(aes(x=long,y=lat,group=group, fill=Default_Rate)) +
  geom_polygon(color = "gray90", size = 0.1) +
  coord_map(projection = "albers", lat0 = 45, lat1 = 55) +
```

```
  scale_fill_continuous(type = "viridis", breaks = c(0.10, 0.17, 0.24, 0.31, 0.38))+
  labs(title = "Default Rate of Loan by States in Continental US",
       fill = "Default Rate") +
  theme(legend.position="right",
        axis.line=element_blank(),
        axis.text=element_blank(),
        axis.ticks=element_blank(),
        axis.title=element_blank(),
        panel.background=element_blank(),
        panel.border=element_blank(),
        panel.grid=element_blank())

cat("\n\n\\pagebreak\n")
cat(text="Table 6.Descriptive of Small Business Loans by Loan Status (III)")
table1(~ApprovalFY|MIS_Status,data=sbl)

cat("\n\n\\pagebreak\n")
cat(text="Table 7.Descriptive of Small Business Loans by Loan Status (IV)")
table1(~factor(Disbursement_Year)|MIS_Status,data=sbl)
```