

IDS_570_HW2

2022-10-23

R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.

When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

```
library(tidyverse)

## -- Attaching packages ----- tidyverse 1.3.2 --
## v ggplot2 3.3.6     v purrr   0.3.4
## v tibble  3.1.8     v dplyr    1.0.9
## v tidyr   1.2.0     v stringr  1.4.1
## v readr   2.1.2     v forcats 0.5.2
## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::filter()  masks stats::filter()
## x dplyr::lag()     masks stats::lag()

library(ggplot2)
library(dplyr)
library(lubridate)

##
## Attaching package: 'lubridate'
##
## The following objects are masked from 'package:base':
##
##     date, intersect, setdiff, union

df <- read_csv("/Users/nithin/Documents/Data mining/lcDataSampleFall122.csv", show_col_types = FALSE )

## Warning: One or more parsing issues, see 'problems()' for details

head(df)

## # A tibble: 6 x 145
##   id    member_id loan_amnt funded~1 funde~2 term   int_r~3 insta~4 grade sub_g~5
##   <lg1> <lg1>      <dbl>    <dbl>    <dbl> <chr>  <dbl> <dbl> <chr> <chr>
## 1 NA      NA        28000    28000   28000 36 m~    5.32   843. A     A1
## 2 NA      NA        6150     6150    6125 36 m~    13.3   208. C     C3
## 3 NA      NA        7200     7200    7200 36 m~    15.0   250. C     C5
```

```

## 4 NA      NA          4750    4750    4750 36 m~   15.3     165. C     C4
## 5 NA      NA          5000    5000    5000 36 m~   12.7     168. C     C2
## 6 NA      NA          9600    9600    9600 36 m~   15.0     333. C     C3
## # ... with 135 more variables: emp_title <chr>, emp_length <chr>,
## #   home_ownership <chr>, annual_inc <dbl>, verification_status <chr>,
## #   issue_d <dttm>, loan_status <chr>, pymnt_plan <chr>, url <lgl>, desc <lgl>,
## #   purpose <chr>, title <chr>, zip_code <chr>, addr_state <chr>, dti <dbl>,
## #   delinq_2yrs <dbl>, earliest_cr_line <chr>, inq_last_6mths <dbl>,
## #   mths_since_last_delinq <dbl>, mths_since_last_record <dbl>, open_acc <dbl>,
## #   pub_rec <dbl>, revol_bal <dbl>, revol_util <dbl>, total_acc <dbl>, ...

glimpse(df)

## Rows: 100,000
## Columns: 145
## $ id                               <lgl> NA, NA, NA, NA, NA, NA, NA, ~
## $ member_id                         <lgl> NA, NA, NA, NA, NA, NA, NA, ~
## $ loan_amnt                         <dbl> 28000, 6150, 7200, 4750, 50~
## $ funded_amnt                       <dbl> 28000, 6150, 7200, 4750, 50~
## $ funded_amnt_inv                  <dbl> 28000, 6125, 7200, 4750, 50~
## $ term                             <chr> "36 months", "36 months", "~"
## $ int_rate                          <dbl> 5.32, 13.33, 14.99, 15.31, ~
## $ installment                       <dbl> 843.22, 208.20, 249.56, 165~
## $ grade                            <chr> "A", "C", "C", "C", "C", "C~
## $ sub_grade                         <chr> "A1", "C3", "C5", "C4", "C2~
## $ emp_title                         <chr> "Financial Advisor", "Chef"~
## $ emp_length                        <chr> "9 years", "6 years", "3 ye~
## $ home_ownership                    <chr> "MORTGAGE", "RENT", "RENT", ~
## $ annual_inc                        <dbl> 140000, 40000, 20000, 30000~
## $ verification_status               <chr> "Source Verified", "Source ~
## $ issue_d                           <dttm> 2015-05-01, 2015-07-01, 20~
## $ loan_status                        <chr> "Fully Paid", "Fully Paid", ~
## $ pymnt_plan                         <chr> "n", "n", "n", "n", "n", "n~
## $ url                              <lgl> NA, NA, NA, NA, NA, NA, NA, ~
## $ desc                             <lgl> NA, NA, NA, NA, NA, NA, NA, ~
## $ purpose                           <chr> "credit_card", "credit_card~
## $ title                            <chr> "Credit card refinancing", ~
## $ zip_code                          <chr> "633xx", "331xx", "060xx", ~
## $ addr_state                         <chr> "MO", "FL", "CT", "NC", "OH~
## $ dti                             <dbl> 12.83, 22.19, 23.44, 3.40, ~
## $ delinq_2yrs                      <dbl> 0, 0, 0, 3, 0, 0, 0, 1, 6, ~
## $ earliest_cr_line                 <chr> "Dec-1994", "Apr-1988", "Au~
## $ inq_last_6mths                   <dbl> 0, 0, 0, 0, 0, 0, 0, 1, 0, ~
## $ mths_since_last_delinq           <dbl> NA, 43, 31, NA, NA, NA, NA, ~
## $ mths_since_last_record           <dbl> NA, NA, NA, 78, 62, NA, NA, ~
## $ open_acc                          <dbl> 16, 6, 7, 5, 9, 12, 7, 11, ~
## $ pub_rec                           <dbl> 0, 0, 0, 1, 1, 0, 0, 0, 0, ~
## $ revol_bal                         <dbl> 74178, 428, 11907, 2797, 83~
## $ revol_util                        <dbl> 41.5, 17.1, 55.6, 20.0, 71.~
## $ total_acc                         <dbl> 31, 14, 18, 13, 30, 33, 9, ~
## $ initial_list_status              <chr> "w", "f", "f", "f", "f", "w~
## $ out_prncp                         <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, ~
## $ out_prncp_inv                     <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, ~
## $ total_pymnt                       <dbl> 29436.890, 7311.160, 8971.9~
```

```

## $ total_pymnt_inv
## $ total_rec_prncp
## $ total_rec_int
## $ total_rec_late_fee
## $ recoveries
## $ collection_recovery_fee
## $ last_pymnt_d
## $ last_pymnt_amnt
## $ next_pymnt_d
## $ last_credit_pull_d
## $ collections_12_mths_ex_med
## $ mths_since_last_major_derog
## $ policy_code
## $ application_type
## $ annual_inc_joint
## $ dti_joint
## $ verification_status_joint
## $ acc_now_delinq
## $ tot_coll_amt
## $ tot_cur_bal
## $ open_acc_6m
## $ open_act_il
## $ open_il_12m
## $ open_il_24m
## $ mths_since_rcnt_il
## $ total_bal_il
## $ il_util
## $ open_rv_12m
## $ open_rv_24m
## $ max_bal_bc
## $ all_util
## $ total_rev_hi_lim
## $ inq_fi
## $ total_cu_tl
## $ inq_last_12m
## $ acc_open_past_24mths
## $ avg_cur_bal
## $ bc_open_to_buy
## $ bc_util
## $ chargeoff_within_12_mths
## $ delinq_amnt
## $ mo_sin_old_il_acct
## $ mo_sin_old_rev_tl_op
## $ mo_sin_rcnt_rev_tl_op
## $ mo_sin_rcnt_tl
## $ mort_acc
## $ mths_since_recent_bc
## $ mths_since_recent_bc_dlq
## $ mths_since_recent_inq
## $ mths_since_recent_revol_delinq
## $ num_accts_ever_120_pd
## $ num_actv_bc_tl
## $ num_actv_rev_tl
## $ num_bc_sats

```

<dbl> 29436.89, 7281.44, 8971.95,~
<dbl> 28000.00, 6150.00, 7200.00,~
<dbl> 1436.89, 1161.16, 1771.95,~
<dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0,~
<dbl> 0.00, 0.00, 0.00, 0.00, 0.0~
<dbl> 0.0000, 0.0000, 0.0000, 0.0~
<chr> "Jul-2016", "Jun-2017", "No~
<dbl> 18483.31, 2739.87, 249.34, ~
<lg1> NA, NA, NA, NA, NA, NA, NA,~
<chr> "Jul-2016", "Aug-2018", "No~
<dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0,~
<dbl> NA, 43, NA, 23, 58, NA, NA,~
<dbl> 1, 1, 1, 1, 1, 1, 1, 1, ~
<chr> "Individual", "Individual",~
<lg1> NA, NA, NA, NA, NA, NA, NA,~
<lg1> NA, NA, NA, NA, NA, NA, NA,~
<lg1> NA, NA, NA, NA, NA, NA, NA,~
<dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0,~
<dbl> 0, 2363, 0, 0, 0, 0, 0, 0, ~
<dbl> 364466, 21157, 11907, 72539~
<dbl> NA, NA, NA, NA, NA, NA, NA,~
<dbl> 136800, 2500, 21400, 13750,~
<dbl> NA, NA, NA, NA, NA, NA, NA,~
<dbl> NA, NA, NA, NA, NA, NA, NA,~
<dbl> NA, NA, NA, NA, NA, NA, NA,~
<dbl> 3, 2, 1, 3, 8, 7, 5, 5, 4, ~
<dbl> 26033, 3526, 1701, 18134, 2~
<dbl> 54787, 409, 2329, 500, 2500~
<dbl> 43.2, 41.6, 82.9, 76.0, 54.~
<dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0,~
<dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0,~
<dbl> 194, 127, NA, 128, 156, 107~
<dbl> 245, 326, 315, 361, 177, 10~
<dbl> 16, 9, 39, 13, 4, 2, 1, 14,~
<dbl> 16, 9, 20, 13, 4, 2, 1, 4, ~
<dbl> 7, 1, 3, 2, 3, 3, 0, 7, 1, ~
<dbl> 16, 25, 47, 43, 13, 8, 45, ~
<dbl> NA, 43, 31, NA, NA, NA, NA,~
<dbl> 15, 9, NA, 13, 7, 7, 16, 5,~
<dbl> NA, 43, 31, NA, NA, NA, NA,~
<dbl> 0, 2, 0, 1, 0, 0, 0, 0, 6, ~
<dbl> 5, 2, 4, 1, 1, 2, 2, 4, 4, ~
<dbl> 7, 3, 6, 3, 6, 5, 3, 4, 8, ~
<dbl> 10, 2, 4, 1, 3, 2, 2, 6, 4, ~

```

## $ num_bc_tl
## $ num_il_tl
## $ num_op_rev_tl
## $ num_rev_accts
## $ num_rev_tl_bal_gt_0
## $ num_sats
## $ num_tl_120dpd_2m
## $ num_tl_30dpd
## $ num_tl_90g_dpd_24m
## $ num_tl_op_past_12m
## $ pct_tl_nvr_dlq
## $ percent_bc_gt_75
## $ pub_rec_bankruptcies
## $ tax_liens
## $ tot_hi_cred_lim
## $ total_bal_ex_mort
## $ total_bc_limit
## $ total_il_high_credit_limit
## $ revol_bal_joint
## $ sec_app_earliest_cr_line
## $ sec_app_inq_last_6mths
## $ sec_app_mort_acc
## $ sec_app_open_acc
## $ sec_app_revol_util
## $ sec_app_open_act_il
## $ sec_app_num_rev_accts
## $ sec_app_chargeoff_within_12_mths
## $ sec_app_collections_12_mths_ex_med
## $ sec_app_mths_since_last_major_derog
## $ hardship_flag
## $ hardship_type
## $ hardship_reason
## $ hardship_status
## $ deferral_term
## $ hardship_amount
## $ hardship_start_date
## $ hardship_end_date
## $ payment_plan_start_date
## $ hardship_length
## $ hardship_dpd
## $ hardship_loan_status
## $ orig_projected_additional_accrued_interest
## $ hardship_payoff_balance_amount
## $ hardship_last_payment_amount
## $ disbursement_method
## $ debt_settlement_flag
## $ debt_settlement_flag_date
## $ settlement_status
## $ settlement_date
## $ settlement_amount
## $ settlement_percentage
## $ settlement_term

```

PART A

1a - What is the goal of predictive models for this? What will be the potential target variables?

```
# Goal of this is to build a model predicting the loan default of potential borrowers.  
# The target variable is loan_status
```

1b - Categorize the attributes

```
#Borrower characteristics - annual_inc, annual_inc_joint, avg_cur_bal, chargeoff_within_12_mths, collec  
#Loan characteristics - grade, id  
#Platform decisions -  
#Loan Performance -
```

Data exploration

2a - What is the proportion of defaults ('charged off' vs 'fully paid' loans) in the data?

```
### (i) How does default rate vary with loan grade? Does it vary with sub-grade? And is this what you w  
df %>% count(loan_status)  
  
## # A tibble: 2 x 2  
##   loan_status     n  
##   <chr>       <int>  
## 1 Charged Off 13785  
## 2 Fully Paid  86215  
  
prop.table(table(df$loan_status))  
  
##  
## Charged Off  Fully Paid  
##      0.13785    0.86215  
  
# 86.2% in the data contains Fully paid and 13.7% contains Charged off  
  
# relationship between Default rate and loan grade  
table(df$loan_status,df$grade)  
  
##  
##          A      B      C      D      E      F      G  
## Charged Off 1187 3723 4738 2858 1010  239   30  
## Fully Paid 21401 30184 21907 9635 2569  469   50
```

```

# Insights : Default(Charged off) gradually increases from grade A to C and then decreases

# relationship between Default rate and sub_grade
table(df$loan_status,df$sub_grade)

##  

##          A1     A2     A3     A4     A5     B1     B2     B3     B4     B5     C1     C2     C3  

## Charged Off 105   116   179   319   468   491   619   825   855   933   978   970   1009  

## Fully Paid  3669  3315  3527  4819  6071  5737  6261  6368  6248  5570  5528  4998  4437  

##  

##          C4     C5     D1     D2     D3     D4     D5     E1     E2     E3     E4     E5     F1  

## Charged Off 927   854   764   644   570   496   384   296   267   180   141   126   63  

## Fully Paid  3730  3214  2776  2162  1939  1515  1243  822   701   471   325   250   189  

##  

##          F2     F3     F4     F5     G1     G2     G3     G4     G5  

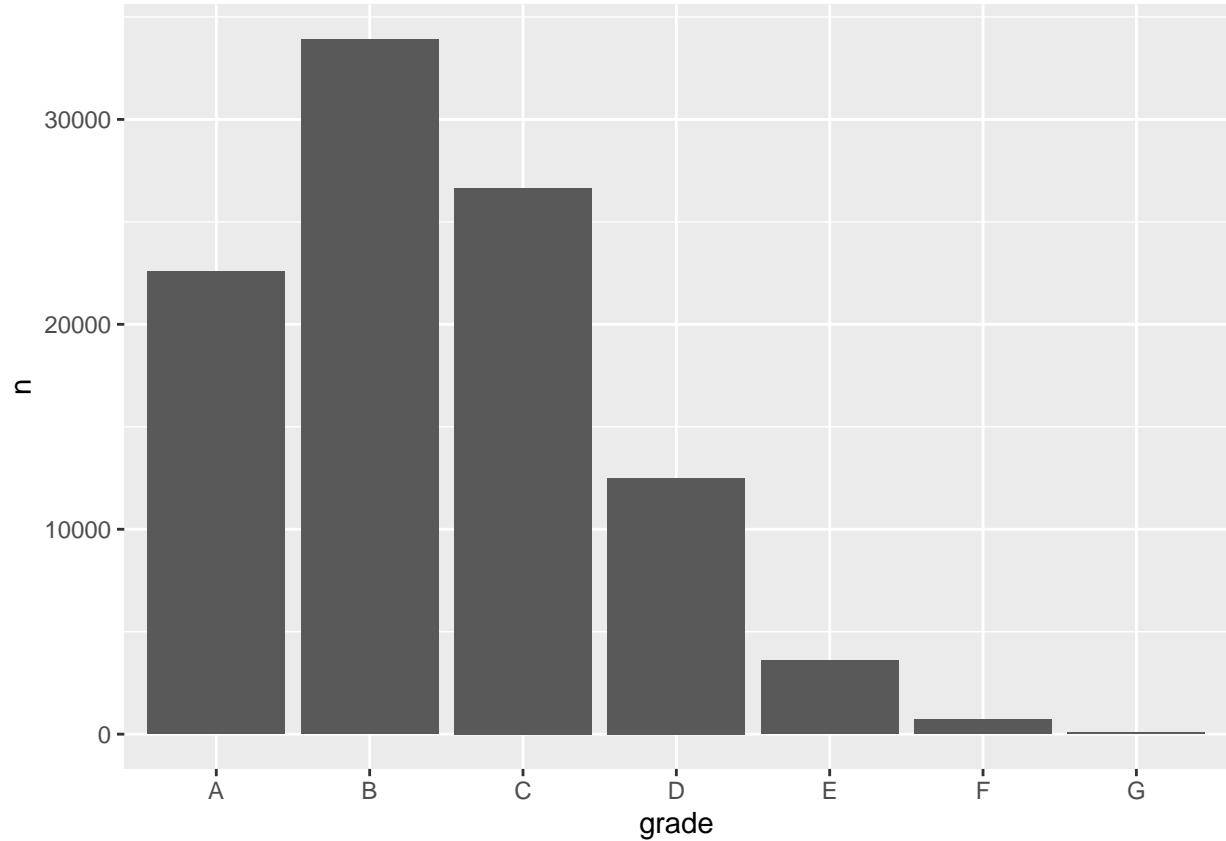
## Charged Off 44    59    47    26    12    9     5     2     2  

## Fully Paid  97   104   50    29    19    12   14    3     2
# insights : Defaults(Charged off) gradually increases from sub_grade A1 to C3 the it decreases
#-----  

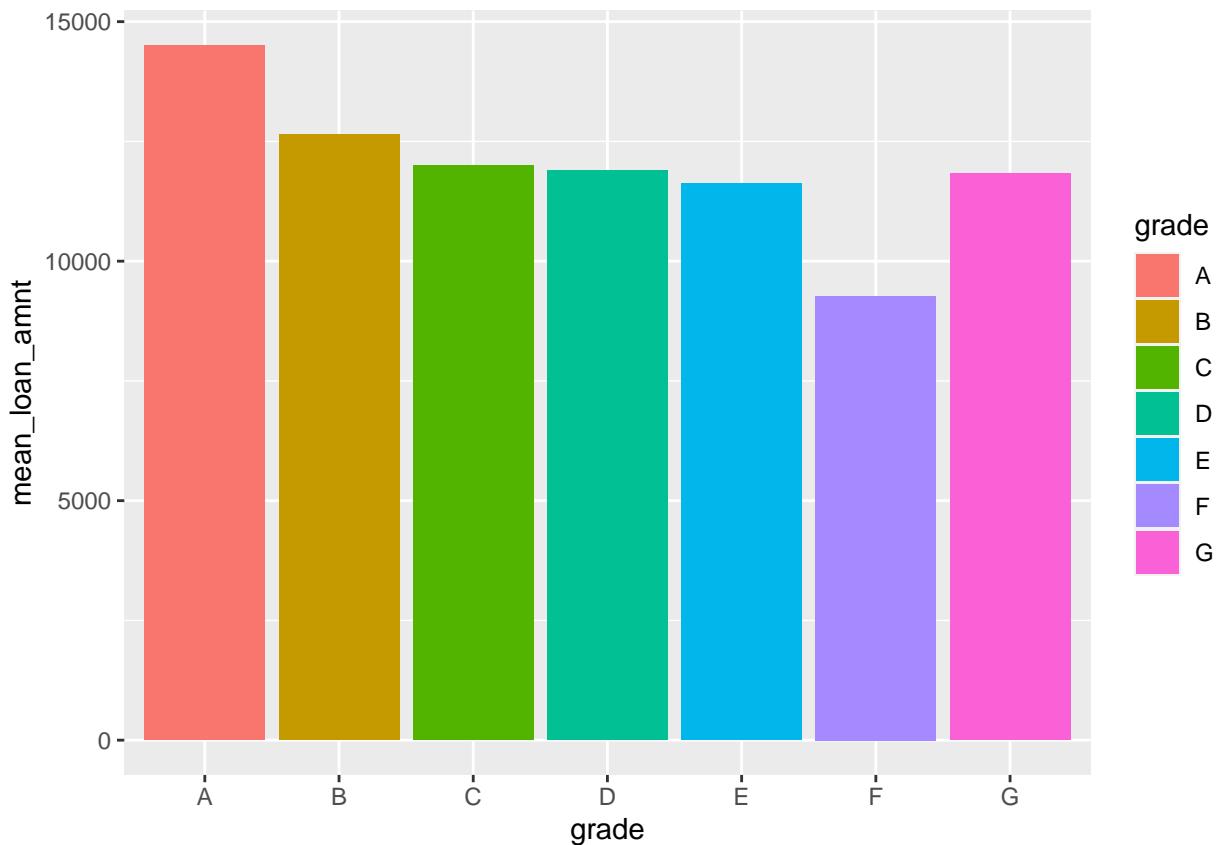
# (ii) How many loans are there in each grade? And do loan amounts vary by grade? Does interest rate fo
```

Count of loans in each grade

```
df_loan_count <- df %>% group_by(grade) %>% count()
ggplot(df_loan_count, aes(x=grade, y =n)) + geom_col()
```



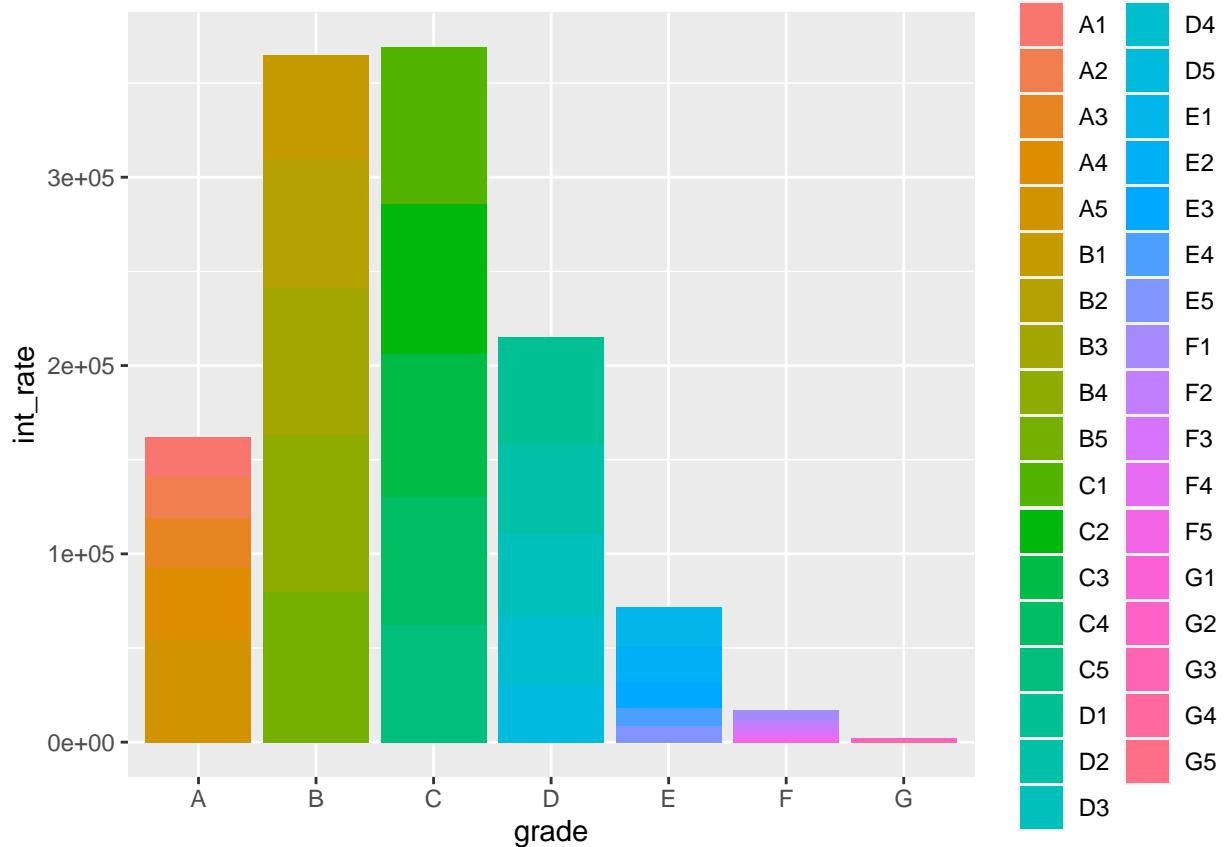
```
# loan amount vs grade
df_loan_amt <- df[c('grade','loan_amnt')] %>% group_by(grade) %>% summarize(mean_loan_amnt = mean(loan_amnt))
ggplot(df_loan_amt, aes(x=grade, y = mean_loan_amnt, fill=grade)) + geom_col()
```



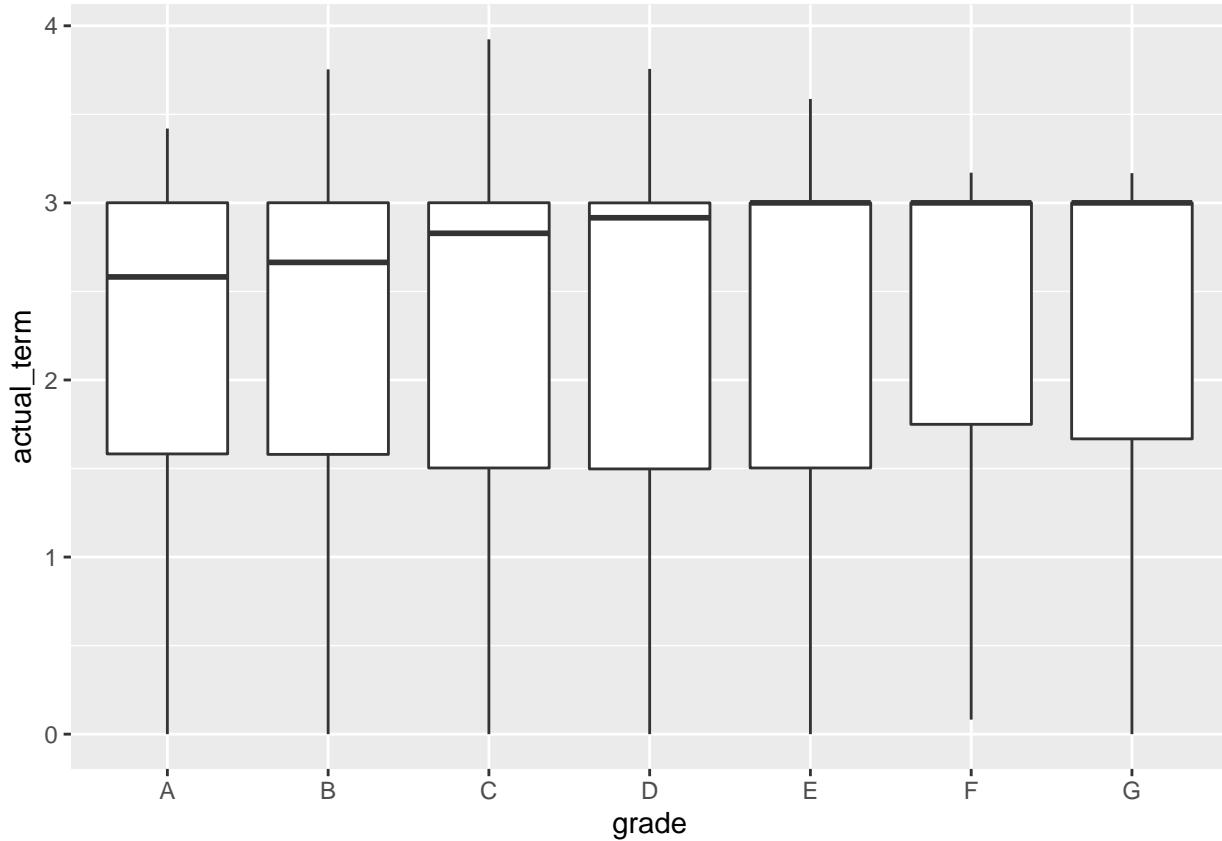
```
# Interest rate vs grade
df_interset <- df[c('grade','sub_grade','int_rate')] %>% group_by(grade,sub_grade) %>% summarise(average)

## `summarise()` has grouped output by 'grade'. You can override using the
## `.` argument.

ggplot(df, aes(x=grade, y =int_rate,fill= sub_grade)) + geom_col()
```



```
#  
  
#(iii) For loans which are fully paid back, how does the time-to-full-payoff vary? For this, calculate  
  
# Changing the columns to required datatypes  
#issue_d is a date variable, while last_pymnt_d is of type character (like "Dec-2018", having month-year)  
#We need to change the character type to date:  
# For these loan we can set actual term at 3  
  
#str(df$issue_d) <- as.Date((df[c("issue_d")]))  
  
# Changing the datatype of last_pymnt_d  
df$last_pymnt_d<-paste(df$last_pymnt_d, "-01", sep = "")  
df$last_pymnt_d<-parse_date_time(df$last_pymnt_d, "myd")  
  
## Warning: 64 failed to parse.  
  
# calculating actual term for 3 years  
df$actual_term <- ifelse(df$loan_status=="Fully Paid", as.duration(df$issue_d %--% df$last_pymnt_d)/days(365), 3)  
  
# Boxplot for actual_term and grade  
ggplot(df, aes(grade,actual_term)) + geom_boxplot()
```



```
#-----
```

```
# (iv) Calculate the annual return. Show how you calculate the percentage annual return.  

# Is there any return from loans which are 'charged off'? Explain. How does return from charged -off loans  

# Compare the average return values with the average interest-rate on loans - do you notice any difference?  

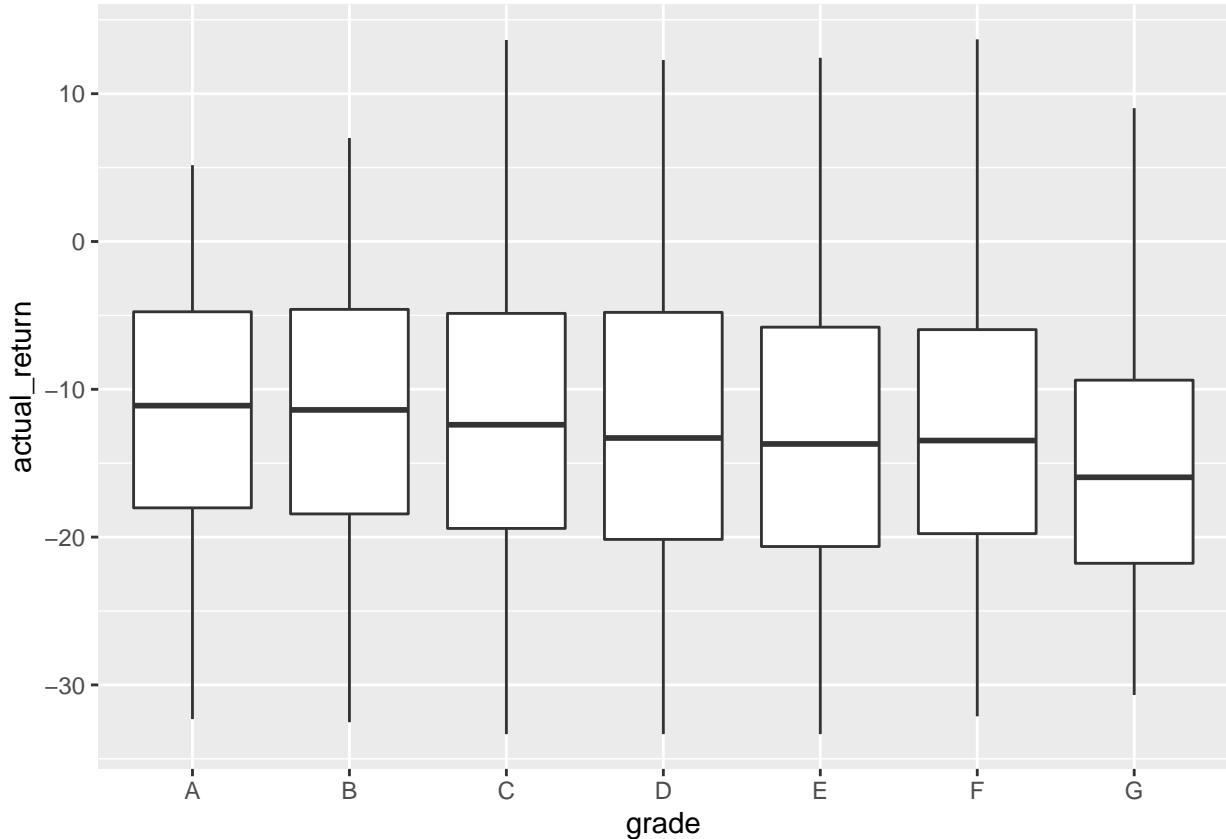
# How do returns vary by grade, and by sub-grade. If you wanted to invest in loans based on this data exp
```

```
df$actual_return <- ifelse(df$actual_term>0, ((df$total_pymnt-df$funded_amnt)/df$funded_amnt)*(1/df$actual_term))

df %>% select(loan_status, int_rate, funded_amnt, total_pymnt, actual_term, actual_return) %>% head()

## # A tibble: 6 x 6
##   loan_status int_rate funded_amnt total_pymnt actual_term actual_return
##   <chr>        <dbl>      <dbl>       <dbl>      <dbl>        <dbl>
## 1 Fully Paid    5.32     28000     29437.     1.17        4.39
## 2 Fully Paid   13.3      6150      7311.     1.92        9.84
## 3 Fully Paid   15.0      7200      8972.     3.00        8.20
## 4 Fully Paid   15.3      4750      5611.     1.42       12.8
## 5 Fully Paid   12.7      5000      6009.     2.59        7.80
## 6 Fully Paid   15.0      9600     11748.     2.16       10.3

# Charged off loan vs grade using Boxplot
df_loangrade_return <- df %>% filter(loan_status=="Charged Off") %>% select(grade,actual_return)
ggplot(df_loangrade_return,aes(x= grade, y = actual_return)) + geom_boxplot()
```



```

# Avg return vs avg interest rate
df_avg_int_return <- df %>% group_by(loan_status) %>% summarise( avg_int_rate=mean(int_rate), total_return=mean(actual_return), avg_actual_term=mean(actual_term) )

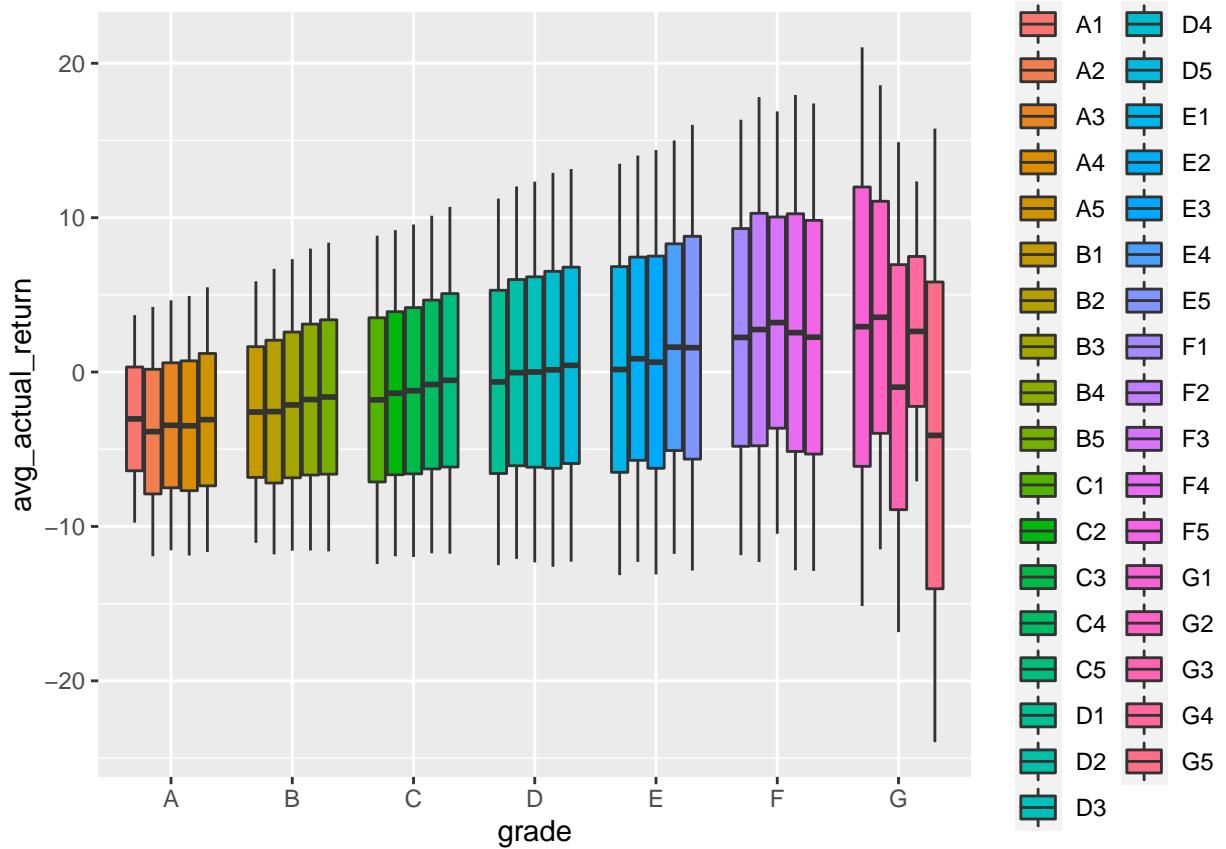
# summary by loan_status, loan grade
df_grade_avgreturn <- df %>% group_by(loan_status,grade) %>% summarise( avg_int_rate=mean(int_rate), total_return=mean(actual_return), avg_actual_term=mean(actual_term) )

## `summarise()` has grouped output by 'loan_status'. You can override using the
## `.` argument.
df_subgrade_avgreturn <- df %>% group_by(loan_status,grade,sub_grade) %>% summarise( avg_int_rate=mean(int_rate), total_return=mean(actual_return), avg_actual_term=mean(actual_term) )

## `summarise()` has grouped output by 'loan_status', 'grade'. You can override
## using the `.` argument.

ggplot(df_subgrade_avgreturn,aes(x= grade, y = avg_actual_return,fill=sub_grade)) + geom_boxplot()

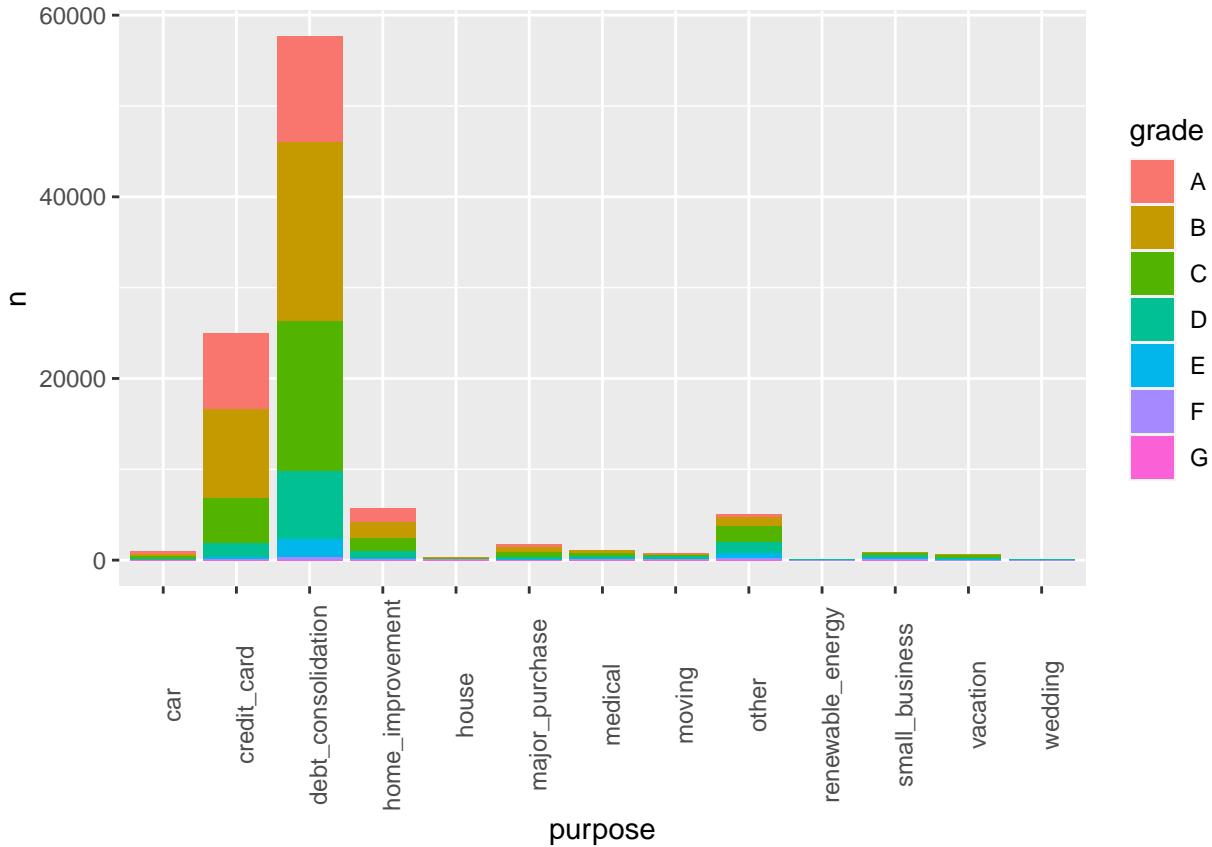
```



```

#-----#
# (v)What are people borrowing money for (purpose)? Examine how many loans, average amounts, etc. by pu
df_purpose <- df %>% group_by(purpose) %>% summarise(loan_count = n(), defaults=sum(loan_status=="Charg
df_purpose_grade <- df %>% count(purpose,grade)
ggplot(df_purpose_grade, aes(x=purpose,y=n,fill=grade)) + geom_col() + theme(axis.text.x = element_text

```



```
# purpose vs home_ownership
table(df$home_ownership, df$purpose)
```

```
##
##          car credit_card debt_consolidation home_improvement house
## MORTGAGE    351        11342                  26978      4282   91
## OWN         127        2566                   5637      909   56
## RENT        450        11081                  25007      463  207
##
##          major_purchase medical moving other renewable_energy small_business
## MORTGAGE       727        493     103  1925           18        388
## OWN          196        123     35  591            8        95
## RENT         900        503     553 2575           32        410
##
##          vacation wedding
## MORTGAGE      253        37
## OWN          85         9
## RENT         340        54
```

(vi) Consider some borrower characteristics like employment-length, annual-income, fico-scores (low, hi)

```
df %>% group_by(emp_length) %>% tally()
```

```
## # A tibble: 12 x 2
```

```

##      emp_length     n
##      <chr>     <int>
## 1 < 1 year     8104
## 2 1 year       6649
## 3 10+ years   31394
## 4 2 years      8987
## 5 3 years      8046
## 6 4 years      5892
## 7 5 years      6046
## 8 6 years      4712
## 9 7 years      5124
## 10 8 years    4990
## 11 9 years    3908
## 12 n/a        6148

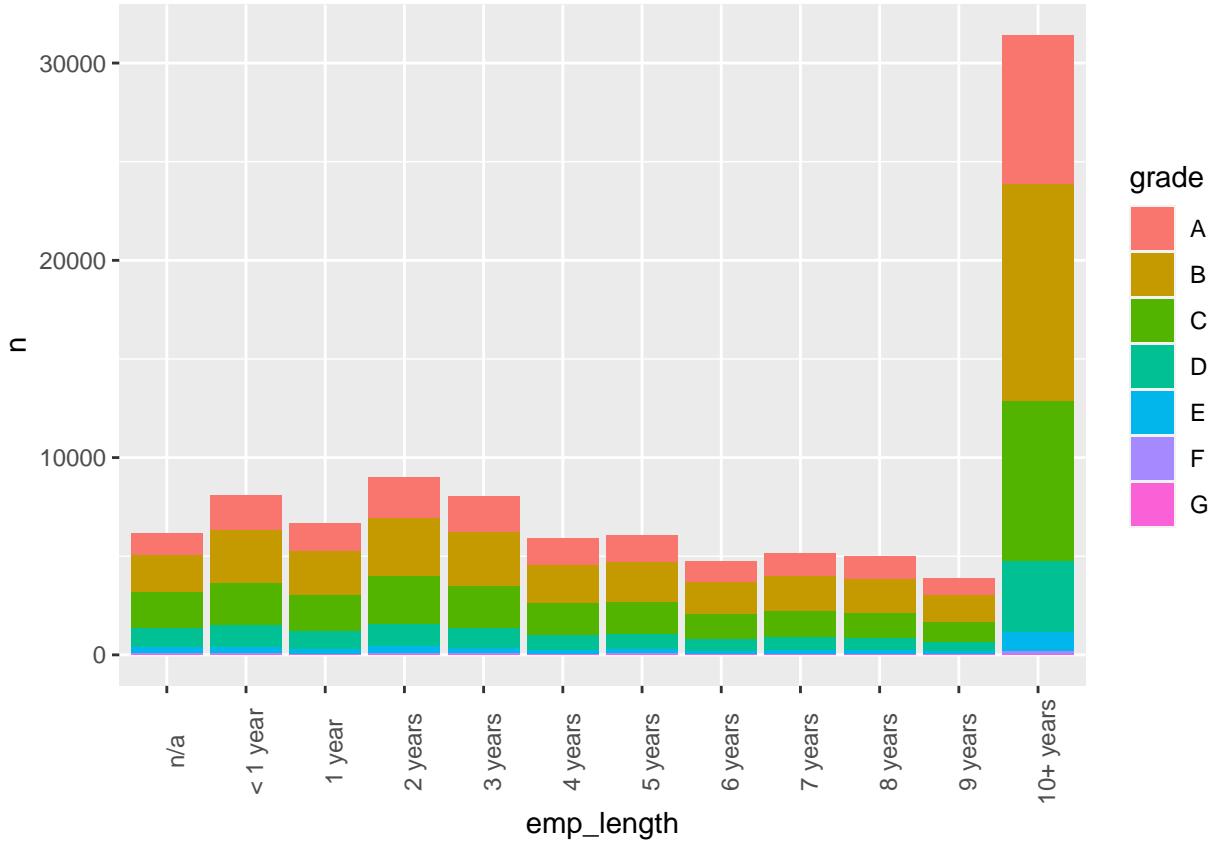
# Converting emp_length to factor
df$emp_length <- factor(df$emp_length, levels=c("n/a", "< 1 year", "1 year", "2 years", "3 years", "4 years", "5 years", "6 years", "7 years", "8 years", "9 years", "10 years", "10+ years"))

# Calculating defaults, default_rate, average interest rate with emp_length
df %>% group_by(emp_length) %>% summarise(nLoans=n(), defaults=sum(loan_status=="Charged Off"), default_rate=defaults/nLoans, avg_int_rate=mean(int_rate), avg_lo~1=mean(amount), avg_a~2=mean(age), avg_a~3=mean(annual_inc))

## # A tibble: 12 x 8
##      emp_length     nLoans defaults default_rate avg_int_rate avg_lo~1 avg_a~2 avg_a~3
##      <fct>     <int>     <int>      <dbl>      <dbl>      <dbl>      <dbl>      <dbl>
## 1 n/a          6148     1296     0.211     12.6    10152.     3.95     2.43
## 2 < 1 year     8104     1204     0.149     12.1    12171.     5.01     2.23
## 3 1 year       6649      960     0.144     12.2    12137.     5.10     2.25
## 4 2 years      8987     1206     0.134     12.1    12252.     5.29     2.22
## 5 3 years      8046     1088     0.135     12.0    12433.     5.31     2.25
## 6 4 years      5892      775     0.132     12.0    12556.     5.37     2.24
## 7 5 years      6046      841     0.139     12.1    12658.     5.28     2.23
## 8 6 years      4712      632     0.134     12.2    12589.     5.48     2.23
## 9 7 years      5124      712     0.139     12.2    12563.     5.39     2.23
## 10 8 years     4990      698     0.140     11.9    13029.     5.17     2.24
## 11 9 years     3908      522     0.134     12.0    13077.     5.19     2.24
## 12 10+ years   31394     3851     0.123     11.8    13741.     5.56     2.24
## # ... with abbreviated variable names 1: avg_loan_amt, 2: avg_act_ret,
## #   3: avg_act_term

#emp_length vs grade
df_emp_grade <- df %>% group_by(emp_length) %>% count(grade)
ggplot(df_emp_grade, aes(x=emp_length, y=n, fill=grade)) + geom_col() + theme(axis.text.x = element_text(angle=45))

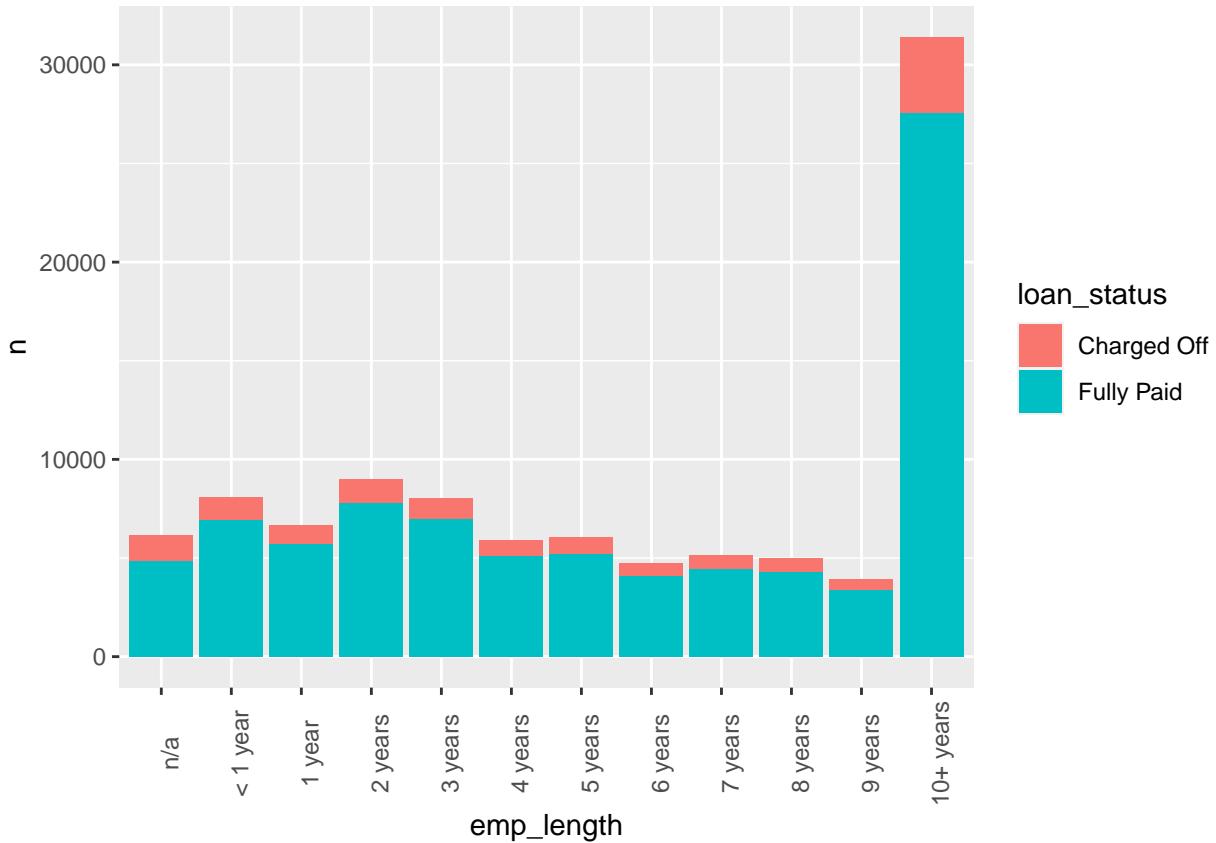
```



```
# emp_length vs loan_status
df_emp_status <- df %>% group_by(emp_length) %>% count(loan_status)
df_emp_status
```

```
## # A tibble: 24 x 3
## # Groups:   emp_length [12]
##   emp_length loan_status     n
##   <fct>      <chr>    <int>
## 1 n/a        Charged Off  1296
## 2 n/a        Fully Paid  4852
## 3 < 1 year   Charged Off  1204
## 4 < 1 year   Fully Paid  6900
## 5 1 year    Charged Off   960
## 6 1 year    Fully Paid  5689
## 7 2 years   Charged Off  1206
## 8 2 years   Fully Paid  7781
## 9 3 years   Charged Off  1088
## 10 3 years  Fully Paid  6958
## # ... with 14 more rows
```

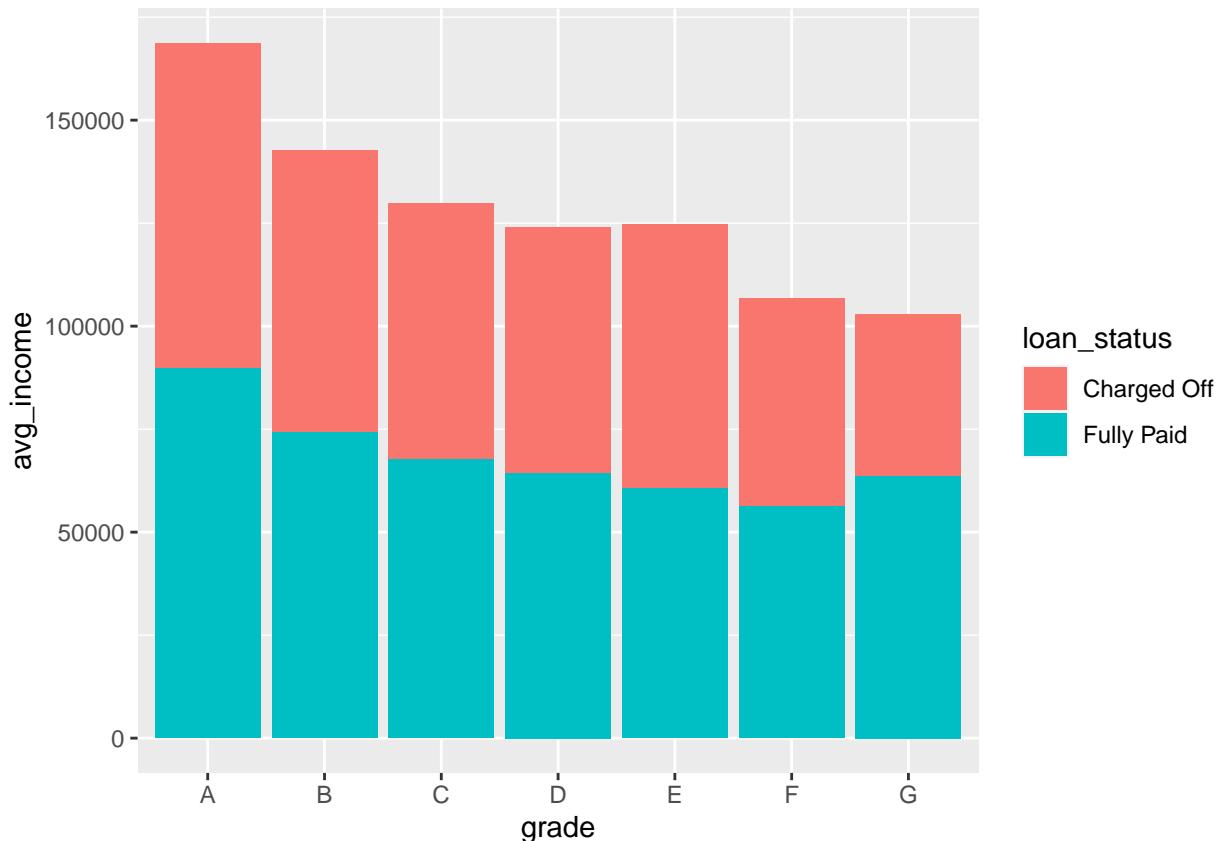
```
ggplot(df_emp_status, aes(x=emp_length, y=n, fill=loan_status)) + geom_col() + theme(axis.text.x = element
```



```
# annual income vs loan_status and grade  
df_inc_grade <- df %>% group_by(loan_status, grade) %>% summarise(avg_income = mean(annual_inc))
```

```
## `summarise()` has grouped output by 'loan_status'. You can override using the  
## `.` argument.
```

```
ggplot(df_inc_grade, aes(x=grade, y=avg_income, fill=loan_status)) + geom_col()
```



```

#-----

# (vii) Generate some (at least 3) new derived attributes which you think may be useful for predicting

#Derived attribute: proportion of satisfactory bankcard accounts
df$propSatisBankcardAccts <- ifelse(df$num_bc_tl>0, df$num_bc_sats/df$num_bc_tl, 0)

# calculate the length of borrower's history with LC
# i.e time between earliest_cr_line and issue_d
df$earliest_cr_line<-paste(df$earliest_cr_line, "-01", sep = "")
df$earliest_cr_line<-parse_date_time(df$earliest_cr_line, "myd")

df$borrHistory <- as.duration(df$earliest_cr_line %--% df$issue_d ) / dyears(1)

#Another new attribute: ratio of openAccounts to totalAccounts
df$openAccRatio <- df$open_acc/df$total_acc

#LC-assigned loan grade vary by borrHistory?
df %>% group_by(grade) %>% summarise(avgBorrHist=mean(borrHistory),avgloanamt = mean(loan_amnt), avgint=mean(int_rate))

## # A tibble: 7 x 4
##   grade avgBorrHist avgloanamt avgintrate
##   <chr>      <dbl>     <dbl>       <dbl>
## 1 A          18.2     14505.       7.17
## 2 B          16.7     12637.      10.8 
## 3 C          15.5     12001.      13.8 
```

```

## 4 D          14.9    11894.    17.2
## 5 E          14.4    11619.    19.9
## 6 F          13.5    9272.    24.0
## 7 G          11.4    11826.    26.4

# loan status vary by borrower's histroy
df %>% group_by(loan_status) %>% summarise(avgBorrHist=mean(borrHistory))

## # A tibble: 2 x 2
##   loan_status avgBorrHist
##   <chr>           <dbl>
## 1 Charged Off     15.6
## 2 Fully Paid      16.5

#LC-assigned loan grade vary by openAccRatio?
df %>% group_by(grade) %>% summarise(avgopenAccRatio = mean(openAccRatio))

## # A tibble: 7 x 2
##   grade avgopenAccRatio
##   <chr>           <dbl>
## 1 A        0.475
## 2 B        0.490
## 3 C        0.515
## 4 D        0.534
## 5 E        0.543
## 6 F        0.584
## 7 G        0.658

#LC-assigned loan grade vary by satisfactory bankcard accounts?
df %>% group_by(grade) %>% summarise(avgpropSatisBankcardAccts = mean(propSatisBankcardAccts))

## # A tibble: 7 x 2
##   grade avgpropSatisBankcardAccts
##   <chr>           <dbl>
## 1 A        0.596
## 2 B        0.602
## 3 C        0.633
## 4 D        0.645
## 5 E        0.642
## 6 F        0.663
## 7 G        0.745

```

(b) Are there missing values? What is the proportion of missing values in different variables? Explain how you will handle missing values for different variables. You should consider what the variable is about, and what missing values may arise from – for example, a variable monthsSinceLastDelinquency may have no value for someone who has not yet had a delinquency;

what is a sensible value to replace the missing values in this case?

Are there some variables you will exclude from your model due to missing values?

```
#To find missing values using colSums  
colSums(is.na(df))
```

```
## id  
## 100000  
## member_id  
## 100000  
## loan_amnt  
## 0  
## funded_amnt  
## 0  
## funded_amnt_inv  
## 0  
## term  
## 0  
## int_rate  
## 0  
## installment  
## 0  
## grade  
## 0  
## sub_grade  
## 0  
## emp_title  
## 6705  
## emp_length  
## 0  
## home_ownership  
## 0  
## annual_inc  
## 0  
## verification_status  
## 0  
## issue_d  
## 0  
## loan_status
```

```

##          0
##      pymnt_plan
##          0
##          url
##      100000
##          desc
##      100000
##          purpose
##          0
##          title
##          12
##      zip_code
##          0
##      addr_state
##          0
##          dti
##          0
##      delinq_2yrs
##          0
##      earliest_cr_line
##          0
##      inq_last_6mths
##          0
##      mths_since_last_delinq
##          49919
##      mths_since_last_record
##          82423
##      open_acc
##          0
##      pub_rec
##          0
##      revol_bal
##          0
##      revol_util
##          41
##      total_acc
##          0
##      initial_list_status
##          0
##      out_prncp
##          0
##      out_prncp_inv
##          0
##      total_pymnt
##          0
##      total_pymnt_inv
##          0
##      total_rec_prncp
##          0
##      total_rec_int
##          0
##      total_rec_late_fee
##          0
##      recoveries

```

```

##          0
## collection_recovery_fee
##          0
##          last_pymnt_d
##          64
##          last_pymnt_amnt
##          0
##          next_pymnt_d
##          100000
##          last_credit_pull_d
##          4
## collections_12_mths_ex_med
##          0
## mths_since_last_major_derog
##          71995
##          policy_code
##          0
##          application_type
##          0
## annual_inc_joint
##          100000
##          dti_joint
##          100000
## verification_status_joint
##          100000
## acc_now_delinq
##          0
## tot_coll_amt
##          0
## tot_cur_bal
##          0
## open_acc_6m
##          97313
## open_act_il
##          97313
## open_il_12m
##          97313
## open_il_24m
##          97313
## mths_since_rcnt_il
##          97393
## total_bal_il
##          97313
## il_util
##          97694
## open_rv_12m
##          97313
## open_rv_24m
##          97313
## max_bal_bc
##          97313
## all_util
##          97313
## total_rev_hi_lim

```

```

##          0
##      inq_hi
##      97313
##      total_cu_tl
##      97313
##      inq_last_12m
##      97313
##      acc_open_past_24mths
##      0
##      avg_cur_bal
##      2
##      bc_open_to_buy
##      964
##      bc_util
##      1044
##      chargeoff_within_12_mths
##      0
##      delinq_amnt
##      0
##      mo_sin_old_il_acct
##      3620
##      mo_sin_old_rev_tl_op
##      0
##      mo_sin_rcnt_rev_tl_op
##      0
##      mo_sin_rcnt_tl
##      0
##      mort_acc
##      0
##      mths_since_recent_bc
##      911
##      mths_since_recent_bc_dlq
##      74329
##      mths_since_recent_inq
##      10612
##      mths_since_recent_revol_delinq
##      64746
##      num_accts_ever_120_pd
##      0
##      num_actv_bc_tl
##      0
##      num_actv_rev_tl
##      0
##      num_bc_sats
##      0
##      num_bc_tl
##      0
##      num_il_tl
##      0
##      num_op_rev_tl
##      0
##      num_rev_accts
##      1
##      num_rev_tl_bal_gt_0

```

```

##                                     0
##                               num_sats
##                                     0
##                           num_tl_120dpd_2m
##                                     3824
##                           num_tl_30dpd
##                                     0
##                           num_tl_90g_dpd_24m
##                                     0
##                           num_tl_op_past_12m
##                                     0
##                           pct_tl_nvr_dlq
##                                     16
##                           percent_bc_gt_75
##                                     1034
##                           pub_rec_bankruptcies
##                                     0
##                           tax_liens
##                                     0
##                           tot_hi_cred_lim
##                                     0
##                           total_bal_ex_mort
##                                     0
##                           total_bc_limit
##                                     0
##                           total_il_high_credit_limit
##                                     0
##                           revol_bal_joint
##                                     100000
##                           sec_app_earliest_cr_line
##                                     100000
##                           sec_app_inq_last_6mths
##                                     100000
##                           sec_app_mort_acc
##                                     100000
##                           sec_app_open_acc
##                                     100000
##                           sec_app_revol_util
##                                     100000
##                           sec_app_open_act_il
##                                     100000
##                           sec_app_num_rev_accts
##                                     100000
##                           sec_app_chargeoff_within_12_mths
##                                     100000
##                           sec_app_collections_12_mths_ex_med
##                                     100000
##                           sec_app_mths_since_last_major_derog
##                                     100000
##                           hardship_flag
##                                     0
##                           hardship_type
##                                     100000
##                           hardship_reason

```

```

##          100000
##      hardship_status
##          100000
##      deferral_term
##          100000
##      hardship_amount
##          100000
##      hardship_start_date
##          100000
##      hardship_end_date
##          100000
##      payment_plan_start_date
##          100000
##      hardship_length
##          100000
##      hardship_dpd
##          99955
##      hardship_loan_status
##          100000
## orig_projected_additional_accrued_interest
##          100000
##      hardship_payoff_balance_amount
##          100000
##      hardship_last_payment_amount
##          100000
##      disbursement_method
##          0
##      debt_settlement_flag
##          0
##      debt_settlement_flag_date
##          100000
##      settlement_status
##          100000
##      settlement_date
##          100000
##      settlement_amount
##          100000
##      settlement_percentage
##          100000
##      settlement_term
##          99535
##      actual_term
##          0
##      actual_return
##          0
##      propSatisBankcardAccts
##          0
##      borrHistory
##          0
##      openAccRatio
##          0
##
```

```
# There are few variables which are completely null so we are removing those
df_final <- df %>% select_if(function(x){ ! all(is.na(x))})
```

```

dim(df_final)

## [1] 100000    113

# Removed 37 variables which had 100% missing values

# To find the names of the columns with missing values
names(df_final)[colSums(is.na(df_final)) > 0]

## [1] "emp_title"                      "title"
## [3] "mths_since_last_delinq"          "mths_since_last_record"
## [5] "revol_util"                     "last_pymnt_d"
## [7] "last_credit_pull_d"              "mths_since_last_major_derog"
## [9] "open_acc_6m"                    "open_act_il"
## [11] "open_il_12m"                   "open_il_24m"
## [13] "mths_since_rcnt_il"             "total_bal_il"
## [15] "il_util"                       "open_rv_12m"
## [17] "open_rv_24m"                   "max_bal_bc"
## [19] "all_util"                      "inq_fi"
## [21] "total_cu_tl"                  "inq_last_12m"
## [23] "avg_cur_bal"                  "bc_open_to_buy"
## [25] "bc_util"                       "mo_sin_old_il_acct"
## [27] "mths_since_recent_bc"           "mths_since_recent_bc_dlq"
## [29] "mths_since_recent_inq"          "mths_since_recent_revol_delinq"
## [31] "num_rev_accts"                 "num_tl_120dpd_2m"
## [33] "pct_tl_nvr_dlq"                "percent_bc_gt_75"
## [35] "hardship_dpd"                  "settlement_term"

#To find percentage of missing values in each column
colMeans(is.na(df_final))* 100

##          loan_amnt      funded_amnt
##            0.000        0.000
## funded_amnt_inv          term
##            0.000        0.000
##          int_rate     installment
##            0.000        0.000
##          grade       sub_grade
##            0.000        0.000
##         emp_title     emp_length
##            6.705        0.000
## home_ownership     annual_inc
##            0.000        0.000
## verification_status     issue_d
##            0.000        0.000
##         loan_status     pymnt_plan
##            0.000        0.000
##          purpose       title
##            0.000        0.012
##         zip_code       addr_state
##            0.000        0.000
##            dti        delinq_2yrs

```

```

##          0.000          0.000
##      earliest_cr_line      inq_last_6mths
##          0.000          0.000
##      mths_since_last_delinq      mths_since_last_record
##          49.919          82.423
##      open_acc      pub_rec
##          0.000          0.000
##      revol_bal      revol_util
##          0.000          0.041
##      total_acc      initial_list_status
##          0.000          0.000
##      out_prncp      out_prncp_inv
##          0.000          0.000
##      total_pymnt      total_pymnt_inv
##          0.000          0.000
##      total_rec_prncp      total_rec_int
##          0.000          0.000
##      total_rec_late_fee      recoveries
##          0.000          0.000
##      collection_recovery_fee      last_pymnt_d
##          0.000          0.064
##      last_pymnt_amnt      last_credit_pull_d
##          0.000          0.004
##      collections_12_mths_ex_med      mths_since_last_major_derog
##          0.000          71.995
##      policy_code      application_type
##          0.000          0.000
##      acc_now_delinq      tot_coll_amt
##          0.000          0.000
##      tot_cur_bal      open_acc_6m
##          0.000          97.313
##      open_act_il      open_il_12m
##          97.313          97.313
##      open_il_24m      mths_since_rcnt_il
##          97.313          97.393
##      total_bal_il      il_util
##          97.313          97.694
##      open_rv_12m      open_rv_24m
##          97.313          97.313
##      max_bal_bc      all_util
##          97.313          97.313
##      total_rev_hi_lim      inq_fi
##          0.000          97.313
##      total_cu_tl      inq_last_12m
##          97.313          97.313
##      acc_open_past_24mths      avg_cur_bal
##          0.000          0.002
##      bc_open_to_buy      bc_util
##          0.964          1.044
##      chargeoff_within_12_mths      delinq_amnt
##          0.000          0.000
##      mo_sin_old_il_acct      mo_sin_old_rev_tl_op
##          3.620          0.000
##      mo_sin_rcnt_rev_tl_op      mo_sin_rcnt_tl

```

```

##          0.000          0.000
##      mort_acc mths_since_recent_bc
##          0.000          0.911
##      mths_since_recent_bc_dlq mths_since_recent_inq
##          74.329          10.612
##  mths_since_recent_revol_delinq num_accts_ever_120_pd
##          64.746          0.000
##      num_actv_bc_tl num_actv_rev_tl
##          0.000          0.000
##      num_bc_sats num_bc_tl
##          0.000          0.000
##      num_il_tl num_op_rev_tl
##          0.000          0.000
##      num_rev_accts num_rev_tl_bal_gt_0
##          0.001          0.000
##      num_sats num_tl_120dpd_2m
##          0.000          3.824
##      num_tl_30dpd num_tl_90g_dpd_24m
##          0.000          0.000
##      num_tl_op_past_12m pct_tl_nvr_dlq
##          0.000          0.016
##      percent_bc_gt_75 pub_rec_bankruptcies
##          1.034          0.000
##      tax_liens tot_hi_cred_lim
##          0.000          0.000
##      total_bal_ex_mort total_bc_limit
##          0.000          0.000
##      total_il_high_credit_limit hardship_flag
##          0.000          0.000
##      hardship_dpd disbursement_method
##          99.955          0.000
##      debt_settlement_flag settlement_term
##          0.000          99.535
##      actual_term actual_return
##          0.000          0.000
##      propSatisBankcardAccts borrHistory
##          0.000          0.000
##      openAccRatio
##          0.000

# There are 4 ways we can handle missing values
#1. Remove rows
#2. Replace with mean or median
#3. Replace with range limit
#4. Replace with other values based on domain language or data set knowledge

#We can replace missing values in a variable with replace_na()
df_final$open_acc_6m <- as.character(df_final$open_acc_6m)
replace_na( df_final$open_acc_6m, "missing")

## [1] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [8] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [15] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [22] "0"       "missing" "missing" "missing" "missing" "missing" "missing"

```



```

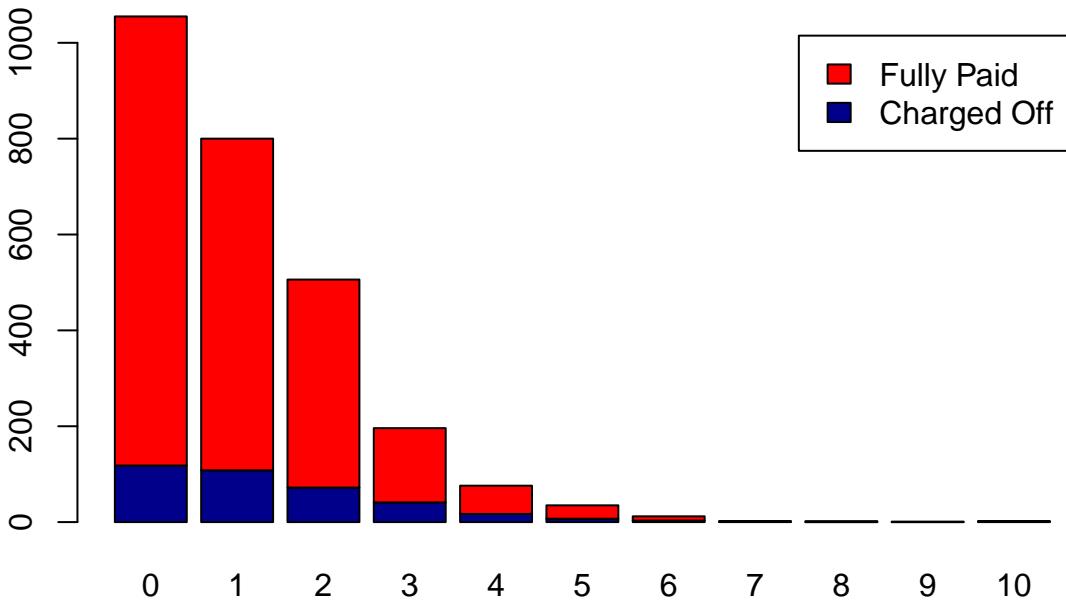
## [99821] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99828] "missing" "2"      "missing" "missing" "missing" "missing" "missing"
## [99835] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99842] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99849] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99856] "missing" "missing" "missing" "missing" "missing" "0"      "missing"
## [99863] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99870] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99877] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99884] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99891] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99898] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99905] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99912] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99919] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99926] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99933] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99940] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99947] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99954] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99961] "missing" "3"      "missing" "missing" "0"      "missing" "missing"
## [99968] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99975] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99982] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99989] "missing" "missing" "missing" "missing" "missing" "missing" "missing"
## [99996] "missing" "missing" "missing" "missing" "missing" "missing"

```

```

# barplot for loan status and open_acc_6
df_loan_open_acc <- table(df$loan_status,df$open_acc_6m)
barplot(df_loan_open_acc, col=c("darkblue","red"),legend = rownames(df_loan_open_acc)) # here, one bar

```



```
# Variable mths_since_last_record has more than 80% values missing
df_mths_since<-table( df_final$loan_status, replace_na( as.character(df_final$mths_since_last_delinq),
df_mths_since[1,]/(df_mths_since[2,]+df_mths_since[1,]))
```

```
##          0           1          10         101         106         107         108         109
## 0.1415929 0.1418093 0.1471572 0.0000000 0.0000000 0.0000000 0.0000000 0.5000000
##          11          110          114          115          116          118          12          120
## 0.1657638 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.1409736 0.0000000
##          124          127          13          130          133          137          14          15
## 0.0000000 0.0000000 0.1385100 0.0000000 0.0000000 0.0000000 0.1502146 0.1563786
##          152          16          17          176          18          188          19          2
## 1.0000000 0.1563927 0.1321839 0.0000000 0.1516165 0.0000000 0.1265060 0.1569507
##          20          21          22          23          24          25          26          27
## 0.1420188 0.1516919 0.1348315 0.1310680 0.1666667 0.1442911 0.1469816 0.1329987
##          28          29           3          30          31          32          33          34
## 0.1319797 0.1395647 0.1478873 0.1291611 0.1382550 0.1594828 0.1609354 0.1478382
##          35          36          37          38          39           4          40          41
## 0.1246612 0.1387283 0.1360856 0.1263001 0.1450382 0.1430678 0.1633888 0.1329305
##          42          43          44          45          46          47          48          49
## 0.1379310 0.1470113 0.1361502 0.1435115 0.1210084 0.1304348 0.1276596 0.1375246
##          5           50          51          52          53          54          55          56
## 0.1521197 0.1247216 0.1587678 0.1627358 0.1428571 0.1648107 0.1204819 0.1305361
##          57          58          59           6          60          61          62          63
## 0.1574074 0.1277533 0.1530172 0.1424390 0.1631206 0.1490826 0.1622276 0.1421189
##          64          65          66          67          68          69           7          70
```

```

## 0.1363636 0.1626794 0.1467391 0.1398964 0.1250000 0.1237113 0.1409043 0.1825193
##    71      72      73      74      75      76      77      78
## 0.1479452 0.1693122 0.1577540 0.1554878 0.1368421 0.1464174 0.1386139 0.1058394
##    79      8      80      81      82      83      84      85
## 0.1226994 0.1427156 0.1241379 0.1363636 0.1616162 0.2727273 0.2000000 0.1111111
##    86      87      88      89      9      90      91      92
## 0.1428571 0.1428571 0.0000000 0.0000000 0.1351085 1.0000000 0.0000000 0.0000000
##    93      94      95      96      98      99 missing
## 0.0000000 0.0000000 0.0000000 0.0000000 0.3333333 0.1323744

```

#For mths_since_last_delinq, which has around 50% values missing

```

df_mths_since_delinq<-table( df_final$loan_status, replace_na( as.character(df_final$mths_since_last_delinq[1,])/(df_mths_since_delinq[2,]+df_mths_since_delinq[1,]))
```

```

##      0      1     10    101    106    107    108    109
## 0.1415929 0.1418093 0.1471572 0.0000000 0.0000000 0.0000000 0.0000000 0.5000000
##     11     110    114    115    116    118     12    120
## 0.1657638 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.1409736 0.0000000
##    124     127     13    130    133    137     14     15
## 0.0000000 0.0000000 0.1385100 0.0000000 0.0000000 0.0000000 0.1502146 0.1563786
##    152      16     17    176     18    188     19      2
## 1.0000000 0.1563927 0.1321839 0.0000000 0.1516165 0.0000000 0.1265060 0.1569507
##     20     21     22     23     24     25     26     27
## 0.1420188 0.1516919 0.1348315 0.1310680 0.1666667 0.1442911 0.1469816 0.1329987
##     28     29      3     30     31     32     33     34
## 0.1319797 0.1395647 0.1478873 0.1291611 0.1382550 0.1594828 0.1609354 0.1478382
##     35     36     37     38     39      4     40     41
## 0.1246612 0.1387283 0.1360856 0.1263001 0.1450382 0.1430678 0.1633888 0.1329305
##     42     43     44     45     46     47     48     49
## 0.1379310 0.1470113 0.1361502 0.1435115 0.1210084 0.1304348 0.1276596 0.1375246
##      5     50     51     52     53     54     55     56
## 0.1521197 0.1247216 0.1587678 0.1627358 0.1428571 0.1648107 0.1204819 0.1305361
##     57     58     59      6     60     61     62     63
## 0.1574074 0.1277533 0.1530172 0.1424390 0.1631206 0.1490826 0.1622276 0.1421189
##     64     65     66     67     68     69      7     70
## 0.1363636 0.1626794 0.1467391 0.1398964 0.1250000 0.1237113 0.1409043 0.1825193
##     71     72     73     74     75     76     77     78
## 0.1479452 0.1693122 0.1577540 0.1554878 0.1368421 0.1464174 0.1386139 0.1058394
##     79      8     80     81     82     83     84     85
## 0.1226994 0.1427156 0.1241379 0.1363636 0.1616162 0.2727273 0.2000000 0.1111111
##     86     87     88     89      9     90     91     92
## 0.1428571 0.1428571 0.0000000 0.0000000 0.1351085 1.0000000 0.0000000 0.0000000
##     93     94     95     96     98     99 missing
## 0.0000000 0.0000000 0.0000000 0.0000000 0.3333333 0.1323744

```

#Here, there is a pattern of higher defaults for examples which have more recent delinquencies. We show

#For mths_since_recent_inq, which has around 10% values missing

```

df_mths_since_inq<-table( df_final$loan_status, replace_na( as.character(df_final$mths_since_recent_inq[1,])/(df_mths_since_inq[2,]+df_mths_since_inq[1,]))
```

```

##      0      1      10     11      12      13      14
## 0.17605634 0.17604923 0.12937371 0.12959894 0.11919120 0.12579365 0.12564706

```

```

##      15      16      17      18      19      2      20
## 0.13487372 0.11476427 0.10687023 0.10178306 0.10517529 0.14735672 0.09487666
##      21      22      23      24      3      4      5
## 0.10810811 0.11097993 0.09867629 0.09685230 0.15962441 0.14582710 0.14701378
##      6       7       8       9    missing
## 0.14672686 0.12820004 0.12851406 0.12370868 0.09696570

# Here, the proportion of defaults for missing values seem similar to the larger values of the variables

#Suppose you decide to remove variables which have more than 60% missing values
nm<-names(df_final)[colMeans(is.na(df_final))>0.9]
df_final <- df_final %>% select(-all_of(nm))
# Here we removed 20 columns

#To replace the few missing values in a column by the column median values
# storing this in temp dataframe
lcx <- df_final #copy to lcx
lcx<- lcx %>% mutate_if(is.numeric, ~ifelse(is.na(.x), median(.x, na.rm = TRUE), .x))
summary(lcx)

##      loan_amnt      funded_amnt      funded_amnt_inv      term
##  Min.   : 1000   Min.   : 1000   Min.   : 925   Length:100000
##  1st Qu.: 7000   1st Qu.: 7000   1st Qu.: 7000   Class :character
##  Median :10000   Median :10000   Median :10000   Mode  :character
##  Mean   :12736   Mean   :12736   Mean   :12731
##  3rd Qu.:17000   3rd Qu.:17000   3rd Qu.:16975
##  Max.   :35000   Max.   :35000   Max.   :35000
##
##      int_rate      installment      grade      sub_grade
##  Min.   : 5.32   Min.   : 30.12   Length:100000   Length:100000
##  1st Qu.: 8.90   1st Qu.: 227.60  Class :character  Class :character
##  Median :11.99   Median : 347.74  Mode  :character  Mode  :character
##  Mean   :12.01   Mean   : 421.77
##  3rd Qu.:14.47   3rd Qu.: 557.94
##  Max.   :28.99   Max.   :1407.01
##
##      emp_title      emp_length      home_ownership      annual_inc
##  Length:100000   10+ years:31394   Length:100000   Min.   : 3600
##  Class :character 2 years   : 8987   Class :character  1st Qu.: 43000
##  Mode  :character < 1 year  : 8104   Mode  :character  Median : 60600
##                      3 years   : 8046
##                      1 year   : 6649
##                      n/a     : 6148
##                      (Other)  :30672
##  Mean   : 73356
##  3rd Qu.: 89000
##  Max.   :8500021
##
##      verification_status      issue_d      loan_status
##  Length:100000   Min.   :2013-01-01 00:00:00.00   Length:100000
##  Class :character 1st Qu.:2014-04-01 00:00:00.00   Class :character
##  Mode  :character Median :2015-01-01 00:00:00.00   Mode  :character
##                      Mean   :2014-10-29 08:24:51.83
##                      3rd Qu.:2015-07-01 00:00:00.00
##                      Max.   :2015-12-01 00:00:00.00
##
##      pymnt_plan      purpose      title      zip_code
##  Length:100000   Length:100000   Length:100000   Length:100000

```

```

##  Class :character  Class :character  Class :character  Class :character
##  Mode  :character  Mode  :character  Mode  :character  Mode  :character
##
##
##
##    addr_state          dti      delinq_2yrs
##  Length:100000      Min.   : 0.00  Min.   : 0.0000
##  Class :character  1st Qu.:11.63  1st Qu.: 0.0000
##  Mode  :character  Median :17.34  Median : 0.0000
##                      Mean   :17.91  Mean   : 0.3341
##                      3rd Qu.:23.81  3rd Qu.: 0.0000
##                      Max.   :71.40  Max.   :21.0000
##
##    earliest_cr_line           inq_last_6mths  mths_since_last_delinq
##  Min.   :1949-06-01 00:00:00.000  Min.   :0.000  Min.   : 0.00
##  1st Qu.:1994-08-01 00:00:00.000  1st Qu.:0.000  1st Qu.: 30.00
##  Median :1999-12-01 00:00:00.000  Median :0.000  Median : 31.00
##  Mean   :1998-06-11 17:59:53.088  Mean   :0.669  Mean   : 32.47
##  3rd Qu.:2003-10-01 00:00:00.000  3rd Qu.:1.000  3rd Qu.: 31.00
##  Max.   :2012-11-01 00:00:00.000  Max.   :6.000  Max.   :188.00
##
##    mths_since_last_record  open_acc      pub_rec      revol_bal
##  Min.   : 0.0      Min.   : 0.00  Min.   : 0.0000  Min.   : 0
##  1st Qu.: 69.0     1st Qu.: 8.00  1st Qu.: 0.0000  1st Qu.: 5896
##  Median : 69.0     Median :10.00  Median : 0.0000  Median :10725
##  Mean   : 69.1     Mean   :11.42  Mean   : 0.2267  Mean   :15795
##  3rd Qu.: 69.0     3rd Qu.:14.00  3rd Qu.: 0.0000  3rd Qu.:18913
##  Max.   :119.0     Max.   :79.00  Max.   :19.0000  Max.   :924579
##
##    revol_util      total_acc      initial_list_status  out_prncp
##  Min.   : 0.00  Min.   : 2.00  Length:100000      Min.   :0
##  1st Qu.: 36.20 1st Qu.: 16.00  Class :character  1st Qu.:0
##  Median : 54.10  Median : 23.00  Mode  :character  Median :0
##  Mean   : 53.75  Mean   : 24.76                    Mean   :0
##  3rd Qu.: 71.80  3rd Qu.: 32.00                    3rd Qu.:0
##  Max.   :153.70  Max.   :162.00                    Max.   :0
##
##    out_prncp_inv  total_pymnt  total_pymnt_inv total_rec_prncp
##  Min.   :0      Min.   : 0      Min.   : 0      Min.   : 0
##  1st Qu.:0      1st Qu.: 6936  1st Qu.: 6935  1st Qu.: 6000
##  Median :0      Median :11471  Median :11470  Median :10000
##  Mean   :0      Mean   :13790  Mean   :13785  Mean   :11757
##  3rd Qu.:0      3rd Qu.:18294  3rd Qu.:18290  3rd Qu.:16000
##  Max.   :0      Max.   :50941  Max.   :50941  Max.   :35000
##
##    total_rec_int  total_rec_late_fee  recoveries      collection_recovery_fee
##  Min.   : 0.0  Min.   : 0.000  Min.   : 0.0  Min.   : 0.00
##  1st Qu.: 841.4 1st Qu.: 0.000  1st Qu.: 0.0  1st Qu.: 0.00
##  Median :1491.7  Median : 0.000  Median : 0.0  Median : 0.00
##  Mean   :1904.2  Mean   : 1.248  Mean   : 127.6  Mean   : 21.14
##  3rd Qu.:2463.6  3rd Qu.: 0.000  3rd Qu.: 0.0  3rd Qu.: 0.00
##  Max.   :15871.0  Max.   :1098.360  Max.   :32321.3  Max.   :4653.81
##

```

```

##   last_pymnt_d           last_pymnt_amnt    last_credit_pull_d
## Min.   :2013-02-01 00:00:00.00  Min.   : 0.0      Length:100000
## 1st Qu.:2016-01-01 00:00:00.00  1st Qu.: 327.8    Class :character
## Median :2016-12-01 00:00:00.00  Median : 976.2    Mode  :character
## Mean   :2016-11-10 01:42:09.68  Mean   : 3486.7
## 3rd Qu.:2017-11-01 00:00:00.00  3rd Qu.: 4993.6
## Max.   :2019-02-01 00:00:00.00  Max.   :36058.7
## NA's    :64

## collections_12_mths_ex_med mths_since_last_major_derog  policy_code
## Min.   :0.0000          Min.   : 0                  Min.   :1
## 1st Qu.:0.0000          1st Qu.: 43                1st Qu.:1
## Median :0.0000          Median : 43                Median :1
## Mean   :0.0167          Mean   : 43                Mean   :1
## 3rd Qu.:0.0000          3rd Qu.: 43                3rd Qu.:1
## Max.   :6.0000          Max.   :188               Max.   :1
##
## application_type acc_now_delinq     tot_coll_amt     tot_cur_bal
## Length:100000      Min.   :0.000000  Min.   : 0.0      Min.   : 0
## Class :character   1st Qu.:0.000000  1st Qu.: 0.0      1st Qu.: 25656
## Mode  :character   Median :0.000000  Median : 0.0      Median : 65143
##                   Mean   :0.00577   Mean   : 232.8     Mean   : 128759
##                   3rd Qu.:0.000000  3rd Qu.: 0.0      3rd Qu.: 191246
##                   Max.   :4.000000  Max.   :262740.0    Max.   :3292113
##
## total_rev_hi_lim acc_open_past_24mths avg_cur_bal      bc_open_to_buy
## Min.   : 0          Min.   : 0.000      Min.   : 0          Min.   : 0
## 1st Qu.: 12800     1st Qu.: 2.000      1st Qu.: 2791     1st Qu.: 1224
## Median : 22000     Median : 4.000      Median : 6312     Median : 3893
## Mean   : 30545     Mean   : 4.396      Mean   : 12470    Mean   : 8997
## 3rd Qu.: 37500     3rd Qu.: 6.000      3rd Qu.: 17266    3rd Qu.: 10491
## Max.   :1165700    Max.   :42.000      Max.   :395953    Max.   :332178
##
## bc_util        chargeoff_within_12_mths delinq_amnt
## Min.   : 0.00      Min.   :0.000000      Min.   : 0.00
## 1st Qu.: 42.70     1st Qu.:0.000000      1st Qu.: 0.00
## Median : 66.20     Median :0.000000      Median : 0.00
## Mean   : 62.49     Mean   :0.01015      Mean   : 12.44
## 3rd Qu.: 86.00     3rd Qu.:0.000000      3rd Qu.: 0.00
## Max.   :188.80     Max.   :6.000000      Max.   :88216.00
##
## mo_sin_old_il_acct mo_sin_old_rev_tl_op mo_sin_rcnt_rev_tl_op
## Min.   : 0.0          Min.   : 3.0          Min.   : 0.00
## 1st Qu.: 97.0         1st Qu.:115.0        1st Qu.: 4.00
## Median :128.0         Median :164.0        Median : 8.00
## Mean   :125.1         Mean   :182.4        Mean   : 13.25
## 3rd Qu.:151.0         3rd Qu.:231.0        3rd Qu.: 16.00
## Max.   :640.0          Max.   :780.0        Max.   :293.00
##
## mo_sin_rcnt_tl       mort_acc      mths_since_recent_bc
## Min.   : 0.000      Min.   : 0.000      Min.   : 0.0
## 1st Qu.: 3.000      1st Qu.: 0.000      1st Qu.: 6.0
## Median : 6.000      Median : 1.000      Median : 14.0
## Mean   : 8.231      Mean   : 1.635      Mean   : 24.4
## 3rd Qu.:10.000      3rd Qu.: 3.000      3rd Qu.: 29.0

```

```

##  Max.   :226.000  Max.   :25.000  Max.   :616.0
##
##  mths_since_recent_bc_dlq mths_since_recent_inq mths_since_recent_revol_delinq
##  Min.   : 0.00          Min.   : 0.000          Min.   : 0.00
##  1st Qu.: 39.00         1st Qu.: 2.000         1st Qu.: 33.00
##  Median : 39.00         Median : 5.000         Median : 33.00
##  Mean   : 39.25         Mean   : 6.706         Mean   : 34.01
##  3rd Qu.: 39.00         3rd Qu.:10.000        3rd Qu.: 33.00
##  Max.   :176.00         Max.   :24.000         Max.   :176.00
##
##  num_accts_ever_120_pd num_actv_bc_tl  num_actv_rev_tl  num_bc_sats
##  Min.   : 0.00000      Min.   : 0.000      Min.   : 0.000      Min.   : 0.000
##  1st Qu.: 0.00000      1st Qu.: 2.000      1st Qu.: 3.000      1st Qu.: 3.000
##  Median : 0.00000      Median : 3.000      Median : 5.000      Median : 4.000
##  Mean   : 0.4969       Mean   : 3.643      Mean   : 5.673      Mean   : 4.653
##  3rd Qu.: 0.00000      3rd Qu.: 5.000      3rd Qu.: 7.000      3rd Qu.: 6.000
##  Max.   :23.00000      Max.   :26.000      Max.   :41.000      Max.   :36.000
##
##  num_bc_tl      num_il_tl      num_op_rev_tl  num_rev_accts
##  Min.   : 0.000      Min.   : 0.000      Min.   : 0.00      Min.   : 2.00
##  1st Qu.: 5.000      1st Qu.: 3.000      1st Qu.: 5.00      1st Qu.: 9.00
##  Median : 7.000      Median : 6.000      Median : 7.00      Median :13.00
##  Mean   : 8.297      Mean   : 8.085      Mean   : 8.16      Mean   :14.76
##  3rd Qu.:11.000      3rd Qu.: 11.000     3rd Qu.:10.00      3rd Qu.:19.00
##  Max.   :61.000      Max.   :132.000     Max.   :67.00      Max.   :87.00
##
##  num_rev_tl_bal_gt_0  num_sats      num_tl_120dpd_2m  num_tl_30dpd
##  Min.   : 0.000      Min.   : 0.00      Min.   :0.00000      Min.   :0.00000
##  1st Qu.: 3.000      1st Qu.: 8.00      1st Qu.:0.00000     1st Qu.:0.00000
##  Median : 5.000      Median :10.00      Median :0.00000     Median :0.00000
##  Mean   : 5.633      Mean   :11.37      Mean   :0.00078     Mean   :0.00383
##  3rd Qu.: 7.000      3rd Qu.:14.00      3rd Qu.:0.00000     3rd Qu.:0.00000
##  Max.   :36.000      Max.   :79.00      Max.   :2.00000      Max.   :4.00000
##
##  num_tl_90g_dpd_24m num_tl_op_past_12m pct_tl_nvr_dlq  percent_bc_gt_75
##  Min.   : 0.00000      Min.   : 0.000      Min.   : 20.00      Min.   : 0.00
##  1st Qu.: 0.00000      1st Qu.: 1.000      1st Qu.: 91.00      1st Qu.: 16.70
##  Median : 0.00000      Median : 2.000      Median : 97.80      Median : 50.00
##  Mean   : 0.09251      Mean   : 2.046      Mean   : 94.05      Mean   : 48.05
##  3rd Qu.: 0.00000      3rd Qu.: 3.000      3rd Qu.:100.00      3rd Qu.: 75.00
##  Max.   :20.00000      Max.   :26.000      Max.   :100.00      Max.   :100.00
##
##  pub_rec_bankruptcies tax_liens      tot_hi_cred_lim  total_bal_ex_mort
##  Min.   : 0.0000      Min.   : 0.00000      Min.   : 0          Min.   : 0
##  1st Qu.: 0.0000      1st Qu.: 0.00000      1st Qu.: 43247    1st Qu.: 18924
##  Median : 0.0000      Median : 0.00000      Median : 93904    Median : 34084
##  Mean   : 0.1376      Mean   : 0.05683      Mean   : 159185   Mean   : 45925
##  3rd Qu.: 0.0000      3rd Qu.: 0.00000      3rd Qu.: 229283   3rd Qu.: 57457
##  Max.   :8.0000      Max.   :18.00000      Max.   :3647089   Max.   :1067947
##
##  total_bc_limit      total_il_high_credit_limit hardship_flag
##  Min.   : 0           Min.   : 0           Length:100000
##  1st Qu.: 7000        1st Qu.: 12142        Class :character
##  Median : 13600       Median : 28353        Mode  :character

```

```

##  Mean    : 20178   Mean    : 38086
##  3rd Qu.: 26000   3rd Qu.: 51262
##  Max.   :332200   Max.   :1027358
##
##  disbursement_method debt_settlement_flag actual_term      actual_return
##  Length:100000       Length:100000       Min.   :0.000   Min.   :-33.333
##  Class :character   Class :character   1st Qu.:1.506   1st Qu.: 4.392
##  Mode  :character   Mode  :character   Median  :2.672   Median  : 6.804
##                                         Mean   :2.249   Mean   : 5.266
##                                         3rd Qu.:3.001   3rd Qu.: 9.454
##                                         Max.   :3.923   Max.   : 44.359
##
##  propSatisBankcardAccts  borrHistory      openAccRatio
##  Min.   :0.0000          Min.   : 3.001   Min.   :0.0000
##  1st Qu.:0.4286          1st Qu.:11.165  1st Qu.:0.3704
##  Median :0.6000          Median :14.831  Median :0.4800
##  Mean   :0.6161          Mean   :16.382  Mean   :0.5014
##  3rd Qu.:0.8000          3rd Qu.:20.246  3rd Qu.:0.6154
##  Max.   :1.0000          Max.   :64.999  Max.   :1.0000
##
# Making the similar changes to the main dataframe
df_final<- df_final %>% mutate_if(is.numeric, ~ifelse(is.na(.x), median(.x, na.rm = TRUE), .x))

# Replacing the missing value with the median of that column
df_final<- df_final %>% replace_na(list(mths_since_last_delinq=-500, bc_open_to_buy=median(df_final$bc_))

#
#Finding the summary of all the variables
nm1<- names(df_final)[colMeans(is.na(df_final))>0]
# we can see that we have removed all the missing values
summary(df_final)

##      loan_amnt      funded_amnt      funded_amnt_inv      term
##  Min.   : 1000   Min.   : 1000   Min.   : 925   Length:100000
##  1st Qu.: 7000   1st Qu.: 7000   1st Qu.: 7000   Class :character
##  Median :10000   Median :10000   Median :10000   Mode  :character
##  Mean   :12736   Mean   :12736   Mean   :12731
##  3rd Qu.:17000   3rd Qu.:17000   3rd Qu.:16975
##  Max.   :35000   Max.   :35000   Max.   :35000
##
##      int_rate      installment      grade      sub_grade
##  Min.   : 5.32   Min.   : 30.12   Length:100000   Length:100000
##  1st Qu.: 8.90   1st Qu.: 227.60  Class :character  Class :character
##  Median :11.99   Median : 347.74  Mode  :character  Mode  :character
##  Mean   :12.01   Mean   : 421.77
##  3rd Qu.:14.47   3rd Qu.: 557.94
##  Max.   :28.99   Max.   :1407.01
##
##      emp_title      emp_length      home_ownership      annual_inc
##  Length:100000   10+ years:31394  Length:100000   Min.   : 3600
##  Class :character 2 years  : 8987   Class :character  1st Qu.: 43000
##  Mode  :character < 1 year : 8104   Mode  :character  Median  : 60600
##                           3 years  : 8046   Mean   : 73356

```

```

##          1 year   : 6649                      3rd Qu.: 89000
##          n/a      : 6148                      Max.    :8500021
##          (Other)   :30672
## verification_status issue_d                  loan_status
## Length:100000      Min.    :2013-01-01 00:00:00.00 Length:100000
## Class  :character  1st Qu.:2014-04-01 00:00:00.00 Class  :character
## Mode   :character  Median :2015-01-01 00:00:00.00 Mode   :character
##                   Mean   :2014-10-29 08:24:51.83
##                   3rd Qu.:2015-07-01 00:00:00.00
##                   Max.    :2015-12-01 00:00:00.00
##
##      pymnt_plan     purpose        title        zip_code
##      Length:100000  Length:100000  Length:100000  Length:100000
##      Class  :character  Class  :character  Class  :character  Class  :character
##      Mode   :character  Mode   :character  Mode   :character  Mode   :character
##
##      addr_state       dti       delinq_2yrs
##      Length:100000  Min.    : 0.00  Min.    : 0.0000
##      Class  :character  1st Qu.:11.63  1st Qu.: 0.0000
##      Mode   :character  Median :17.34  Median : 0.0000
##                   Mean   :17.91  Mean   : 0.3341
##                   3rd Qu.:23.81  3rd Qu.: 0.0000
##                   Max.    :71.40  Max.    :21.0000
##
##      earliest_cr_line           inq_last_6mths  mths_since_last_delinq
##      Min.    :1949-06-01 00:00:00.000  Min.    :0.000  Min.    : 0.00
##      1st Qu.:1994-08-01 00:00:00.000  1st Qu.:0.000  1st Qu.: 30.00
##      Median :1999-12-01 00:00:00.000  Median :0.000  Median : 31.00
##      Mean   :1998-06-11 17:59:53.088  Mean   :0.669  Mean   : 32.47
##      3rd Qu.:2003-10-01 00:00:00.000  3rd Qu.:1.000  3rd Qu.: 31.00
##      Max.    :2012-11-01 00:00:00.000  Max.    :6.000  Max.    :188.00
##
##      mths_since_last_record  open_acc       pub_rec       revol_bal
##      Min.    : 0.0            Min.    : 0.00  Min.    : 0.0000  Min.    : 0
##      1st Qu.: 69.0           1st Qu.: 8.00  1st Qu.: 0.0000  1st Qu.: 5896
##      Median : 69.0           Median :10.00  Median : 0.0000  Median :10725
##      Mean   : 69.1           Mean   :11.42  Mean   : 0.2267  Mean   :15795
##      3rd Qu.: 69.0           3rd Qu.:14.00  3rd Qu.: 0.0000  3rd Qu.:18913
##      Max.    :119.0           Max.    :79.00  Max.    :19.0000  Max.    :924579
##
##      revol_util      total_acc       initial_list_status  out_prncp
##      Min.    : 0.00  Min.    : 2.00  Length:100000  Min.    :0
##      1st Qu.: 36.20  1st Qu.: 16.00  Class  :character  1st Qu.:0
##      Median : 54.10  Median : 23.00  Mode   :character  Median :0
##      Mean   : 53.75  Mean   : 24.76
##      3rd Qu.: 71.80  3rd Qu.: 32.00
##      Max.    :153.70  Max.    :162.00
##
##      out_prncp_inv  total_pymnt    total_pymnt_inv  total_rec_prncp
##      Min.    :0      Min.    : 0      Min.    : 0      Min.    : 0
##      1st Qu.:0      1st Qu.: 6936  1st Qu.: 6935  1st Qu.: 6000

```

```

## Median :0      Median :11471      Median :11470      Median :10000
## Mean   :0      Mean   :13790      Mean   :13785      Mean   :11757
## 3rd Qu.:0      3rd Qu.:18294      3rd Qu.:18290      3rd Qu.:16000
## Max.  :0      Max.  :50941      Max.  :50941      Max.  :35000
##
## total_rec_int      total_rec_late_fee      recoveries      collection_recovery_fee
## Min.   : 0.0      Min.   : 0.000      Min.   : 0.0      Min.   : 0.00
## 1st Qu.: 841.4    1st Qu.: 0.000      1st Qu.: 0.0      1st Qu.: 0.00
## Median :1491.7    Median : 0.000      Median : 0.0      Median : 0.00
## Mean   :1904.2    Mean   : 1.248      Mean   : 127.6     Mean   : 21.14
## 3rd Qu.:2463.6    3rd Qu.: 0.000      3rd Qu.: 0.0      3rd Qu.: 0.00
## Max.  :15871.0    Max.  :1098.360     Max.  :32321.3     Max.  :4653.81
##
## last_pymnt_d          last_pymnt_amnt      last_credit_pull_d
## Min.   :2013-02-01 00:00:00.00  Min.   : 0.0      Length:100000
## 1st Qu.:2016-01-01 00:00:00.00  1st Qu.: 327.8     Class :character
## Median :2016-12-01 00:00:00.00  Median : 976.2     Mode  :character
## Mean   :2016-11-10 01:42:09.68  Mean   : 3486.7
## 3rd Qu.:2017-11-01 00:00:00.00  3rd Qu.: 4993.6
## Max.  :2019-02-01 00:00:00.00  Max.  :36058.7
## NA's   :64
## collections_12_mths_ex_med mths_since_last_major_derog  policy_code
## Min.   :0.0000      Min.   : 0           Min.   :1
## 1st Qu.:0.0000      1st Qu.: 43         1st Qu.:1
## Median :0.0000      Median : 43         Median :1
## Mean   :0.0167      Mean   : 43         Mean   :1
## 3rd Qu.:0.0000      3rd Qu.: 43         3rd Qu.:1
## Max.  :6.0000       Max.  :188        Max.  :1
##
## application_type      acc_now_delinq      tot_coll_amt      tot_cur_bal
## Length:100000      Min.   :0.00000      Min.   : 0.0      Min.   : 0
## Class :character    1st Qu.:0.00000      1st Qu.: 0.0      1st Qu.: 25656
## Mode  :character    Median :0.00000      Median : 0.0      Median : 65143
##                      Mean   :0.00577      Mean   : 232.8     Mean   : 128759
##                      3rd Qu.:0.00000      3rd Qu.: 0.0      3rd Qu.: 191246
##                      Max.  :4.00000      Max.  :262740.0    Max.  :3292113
##
## total_rev_hi_lim  acc_open_past_24mths  avg_cur_bal      bc_open_to_buy
## Min.   : 0      Min.   : 0.000      Min.   : 0      Min.   : 0
## 1st Qu.: 12800  1st Qu.: 2.000      1st Qu.: 2791    1st Qu.: 1224
## Median : 22000  Median : 4.000      Median : 6312    Median : 3893
## Mean   : 30545  Mean   : 4.396      Mean   : 12470   Mean   : 8997
## 3rd Qu.: 37500  3rd Qu.: 6.000      3rd Qu.: 17266   3rd Qu.: 10491
## Max.  :1165700  Max.  :42.000      Max.  :395953   Max.  :332178
##
## bc_util      chargeoff_within_12_mths  delinq_amnt
## Min.   : 0.00  Min.   :0.00000      Min.   : 0.00
## 1st Qu.: 42.70 1st Qu.:0.00000      1st Qu.: 0.00
## Median : 66.20  Median :0.00000      Median : 0.00
## Mean   : 62.49  Mean   :0.01015      Mean   : 12.44
## 3rd Qu.: 86.00  3rd Qu.:0.00000      3rd Qu.: 0.00
## Max.  :188.80  Max.  :6.00000      Max.  :88216.00
##
## mo_sin_old_il_acct mo_sin_old_rev_tl_op mo_sin_rcnt_rev_tl_op

```

```

## Min. : 0.0      Min. : 3.0      Min. : 0.00
## 1st Qu.: 97.0    1st Qu.:115.0    1st Qu.: 4.00
## Median :128.0    Median :164.0    Median : 8.00
## Mean   :125.1    Mean   :182.4    Mean   : 13.25
## 3rd Qu.:151.0    3rd Qu.:231.0    3rd Qu.: 16.00
## Max.   :640.0     Max.   :780.0     Max.   :293.00
##
## mo_sin_rcnt_tl      mort_acc      mths_since_recent_bc
## Min. : 0.0000  Min. : 0.0000  Min. : 0.0
## 1st Qu.: 3.0000  1st Qu.: 0.0000  1st Qu.: 6.0
## Median : 6.0000  Median : 1.0000  Median : 14.0
## Mean   : 8.2310  Mean   : 1.6350  Mean   : 24.4
## 3rd Qu.:10.0000  3rd Qu.: 3.0000  3rd Qu.: 29.0
## Max.   :226.0000  Max.   :25.0000  Max.   :616.0
##
## mths_since_recent_bc_dlq mths_since_recent_inq mths_since_recent_revol_delinq
## Min. : 0.00          Min. : 0.0000        Min. : 0.00
## 1st Qu.: 39.00        1st Qu.: 2.0000       1st Qu.: 33.00
## Median : 39.00        Median : 5.0000       Median : 33.00
## Mean   : 39.25        Mean   : 6.7060       Mean   : 34.01
## 3rd Qu.: 39.00        3rd Qu.:10.0000      3rd Qu.: 33.00
## Max.   :176.00        Max.   :24.0000       Max.   :176.00
##
## num_accts_ever_120_pd num_actv_bc_tl  num_actv_rev_tl  num_bc_sats
## Min. : 0.00000  Min. : 0.0000  Min. : 0.0000  Min. : 0.000
## 1st Qu.: 0.00000  1st Qu.: 2.0000  1st Qu.: 3.0000  1st Qu.: 3.000
## Median : 0.00000  Median : 3.0000  Median : 5.0000  Median : 4.000
## Mean   : 0.4969   Mean   : 3.6430  Mean   : 5.6730  Mean   : 4.653
## 3rd Qu.: 0.00000  3rd Qu.: 5.0000  3rd Qu.: 7.0000  3rd Qu.: 6.000
## Max.   :23.00000  Max.   :26.0000  Max.   :41.0000  Max.   :36.000
##
## num_bc_tl      num_il_tl      num_op_rev_tl  num_rev_accts
## Min. : 0.0000  Min. : 0.0000  Min. : 0.00  Min. : 2.00
## 1st Qu.: 5.0000 1st Qu.: 3.0000  1st Qu.: 5.00  1st Qu.: 9.00
## Median : 7.0000  Median : 6.0000  Median : 7.00  Median :13.00
## Mean   : 8.2970  Mean   : 8.0850  Mean   : 8.16  Mean   :14.76
## 3rd Qu.:11.0000  3rd Qu.:11.0000 3rd Qu.:10.00  3rd Qu.:19.00
## Max.   :61.0000  Max.   :132.0000 Max.   :67.00  Max.   :87.00
##
## num_rev_tl_bal_gt_0  num_sats      num_tl_120dpd_2m  num_tl_30dpd
## Min. : 0.0000  Min. : 0.00  Min. :0.000000  Min. :0.00000
## 1st Qu.: 3.0000  1st Qu.: 8.00  1st Qu.:0.000000  1st Qu.:0.00000
## Median : 5.0000  Median :10.00  Median :0.000000  Median :0.00000
## Mean   : 5.6330  Mean   :11.37  Mean   :0.000780  Mean   :0.00383
## 3rd Qu.: 7.0000  3rd Qu.:14.00  3rd Qu.:0.000000  3rd Qu.:0.00000
## Max.   :36.0000  Max.   :79.00  Max.   :2.000000  Max.   :4.00000
##
## num_tl_90g_dpd_24m num_tl_op_past_12m pct_tl_nvr_dlq  percent_bc_gt_75
## Min. : 0.000000  Min. : 0.0000  Min. : 20.00  Min. : 0.00
## 1st Qu.: 0.000000  1st Qu.: 1.0000  1st Qu.: 91.00  1st Qu.: 16.70
## Median : 0.000000  Median : 2.0000  Median : 97.80  Median : 50.00
## Mean   : 0.092510  Mean   : 2.0460  Mean   : 94.05  Mean   : 48.05
## 3rd Qu.: 0.000000  3rd Qu.: 3.0000  3rd Qu.:100.00  3rd Qu.: 75.00
## Max.   :20.000000  Max.   :26.0000  Max.   :100.00  Max.   :100.00

```

```

## 
## pub_rec_bankruptcies tax_liens tot_hi_cred_lim total_bal_ex_mort
## Min.   :0.0000      Min.   : 0.00000  Min.   :    0  Min.   : 0
## 1st Qu.:0.0000      1st Qu.: 0.00000  1st Qu.: 43247  1st Qu.: 18924
## Median :0.0000      Median : 0.00000  Median : 93904  Median : 34084
## Mean   :0.1376      Mean   : 0.05683  Mean   : 159185  Mean   : 45925
## 3rd Qu.:0.0000      3rd Qu.: 0.00000  3rd Qu.: 229283  3rd Qu.: 57457
## Max.   :8.0000      Max.   :18.00000  Max.   :3647089  Max.   :1067947
##
## total_bc_limit total_il_high_credit_limit hardship_flag
## Min.   : 0  Min.   : 0          Length:100000
## 1st Qu.:7000 1st Qu.: 12142      Class :character
## Median :13600 Median : 28353      Mode  :character
## Mean   :20178 Mean   : 38086
## 3rd Qu.:26000 3rd Qu.: 51262
## Max.   :332200 Max.   :1027358
##
## disbursement_method debt_settlement_flag actual_term actual_return
## Length:100000      Length:100000      Min.   :0.000  Min.   :-33.333
## Class :character    Class :character    1st Qu.:1.506  1st Qu.: 4.392
## Mode  :character    Mode  :character    Median :2.672  Median : 6.804
##                           Mean   :2.249  Mean   : 5.266
##                           3rd Qu.:3.001 3rd Qu.: 9.454
##                           Max.   :3.923  Max.   : 44.359
##
## propSatisBankcardAccts borrHistory openAccRatio
## Min.   :0.0000      Min.   : 3.001  Min.   :0.0000
## 1st Qu.:0.4286      1st Qu.:11.165  1st Qu.:0.3704
## Median :0.6000      Median :14.831  Median :0.4800
## Mean   :0.6161      Mean   :16.382  Mean   :0.5014
## 3rd Qu.:0.8000      3rd Qu.:20.246  3rd Qu.:0.6154
## Max.   :1.0000      Max.   :64.999  Max.   :1.0000
##
glimpse(df_final %>% select(nm1))

## Note: Using an external vector in selections is ambiguous.
## i Use 'all_of(nm1)' instead of 'nm1' to silence this message.
## i See <https://tidyselect.r-lib.org/reference/faq-external-vector.html>.
## This message is displayed once per session.

## Rows: 100,000
## Columns: 4
## $ emp_title      <chr> "Financial Advisor", "Chef", "Swing Manager", NA, "~"
## $ title         <chr> "Credit card refinancing", "Credit card refinancing~"
## $ last_pymnt_d  <dttm> 2016-07-01, 2017-06-01, 2017-11-01, 2015-08-01, 20~
## $ last_credit_pull_d <chr> "Jul-2016", "Aug-2018", "Nov-2017", "Sep-2015", "Oct~
```

#(c) Consider the potential for data leakage. You do not want to include variables in your model which may not be available when applying the model; that is, some data may not be available for new loans before they are funded. Leakage may also arise from variables in the data which may have been updated during the loan period (ie., after the loan is funded). Identify and explain which variables will you exclude from the model.

```

#Drop some variable/columns which are not useful or which we will not use in developing predictive model
#Identify the variables you want to remove

varsToRemove <- c('funded_amnt', 'funded_amnt_inv', 'emp_title','issue_d','zip_code','out_prncp', 'out_pn

# The funded_amnt and funded_amnt_inv are both features about the future the loan has been approved at
#the emp_title feature would be a hard feature to evaluate so we are removing it
#The following 5 variables are all about the future, they inform us about how the repayment is going, o

#Drop them from the lcdf data-frame
df_final <- df_final %>% select(-all_of(varsToRemove))

#Drop all the variables with names starting with "hardship"
df_final <- df_final %>% select(-starts_with("hardship"))

#similarly, all variable starting with "settlement"
df_final <- df_final %>% select(-starts_with("settlement"))

```

#Converting character variables

```

# notice that there are a few character type variables - grade, sub_grade, verification_status,....
# We can convert all of these to factor
df_final <- df_final %>% mutate_if(is.character, as.factor)

```

#3. Do a univariate analyses to determine which variables (from amongst those you decide to consider for the next stage prediction task) will be individually useful for predicting the dependent variable (loan_status). #For this, you need a measure of relationship between the dependent variable and each of the potential predictor variables. #Given loan-status as a binary dependent variable, which measure will you use? From your analyses using this measure, which variables do you think will be useful for predicting loan_status?

```

### Univariate analysis - Finding the summary statistics of each column
#structure of dataframe
str(df_final)

```

```

## tibble [100,000 x 74] (S3:tbl_df/tbl/data.frame)
## $ loan_amnt : num [1:1000000] 28000 6150 7200 4750 5000 9600 1600 12000 25000 4800 ...
## $ int_rate : num [1:1000000] 5.32 13.33 14.99 15.31 12.69 ...
## $ installment : num [1:1000000] 843 208 250 165 168 ...
## $ grade : Factor w/ 7 levels "A","B","C","D",...: 1 3 3 3 3 3 3 2 3 3 ...
## $ sub_grade : Factor w/ 35 levels "A1","A2","A3",...: 1 13 15 14 12 13 13 7 12 11 ...
## $ home_ownership : Factor w/ 3 levels "MORTGAGE","OWN",...: 1 3 3 1 1 1 3 1 1 1 ...
## $ annual_inc : num [1:1000000] 140000 40000 20000 30000 27000 48500 50000 65000 90000 ...
## $ verification_status : Factor w/ 3 levels "Not Verified",...: 2 2 2 3 3 3 3 2 3 1 ...
## $ loan_status : Factor w/ 2 levels "Charged Off",...: 2 2 2 2 2 2 2 2 2 2 ...
## $ pymnt_plan : Factor w/ 1 level "n": 1 1 1 1 1 1 1 1 1 ...
## $ purpose : Factor w/ 13 levels "car","credit_card",...: 2 2 3 4 3 3 3 3 3 9 ...
## $ addr_state : Factor w/ 49 levels "AK","AL","AR",...: 23 10 7 26 34 32 13 41 34 3 ...
## $ dti : num [1:1000000] 12.8 22.2 23.4 3.4 12.3 ...
## $ delinq_2yrs : num [1:1000000] 0 0 0 3 0 0 0 1 6 0 ...
## $ earliest_cr_line : POSIXct[1:1000000], format: "1994-12-01" "1988-04-01" ...
## $ inq_last_6mths : num [1:1000000] 0 0 0 0 0 0 1 0 0 ...

```

```

## $ mths_since_last_delinq : num [1:100000] 31 43 31 31 31 31 31 15 13 31 ...
## $ mths_since_last_record : num [1:100000] 69 69 69 78 62 69 69 69 65 ...
## $ open_acc : num [1:100000] 16 6 7 5 9 12 7 11 14 6 ...
## $ pub_rec : num [1:100000] 0 0 0 1 1 0 0 0 0 1 ...
## $ revol_bal : num [1:100000] 74178 428 11907 2797 8345 ...
## $ revol_util : num [1:100000] 41.5 17.1 55.6 20 71 66.7 67 59.7 73.1 82.4 ...
## $ total_acc : num [1:100000] 31 14 18 13 30 33 9 35 35 13 ...
## $ initial_list_status : Factor w/ 2 levels "f","w": 2 1 1 1 1 2 2 1 1 1 ...
## $ total_pymnt : num [1:100000] 29437 7311 8972 5611 6009 ...
## $ last_pymnt_d : POSIXct[1:100000], format: "2016-07-01" "2017-06-01" ...
## $ collections_12_mths_ex_med : num [1:100000] 0 0 0 0 0 0 0 0 0 0 ...
## $ mths_since_last_major_derog : num [1:100000] 43 43 43 23 58 43 43 43 13 43 ...
## $ acc_now_delinq : num [1:100000] 0 0 0 0 0 0 0 0 0 0 ...
## $ tot_coll_amt : num [1:100000] 0 2363 0 0 0 ...
## $ tot_cur_bal : num [1:100000] 364466 21157 11907 72539 163964 ...
## $ total_rev_hi_lim : num [1:100000] 136800 2500 21400 13750 11800 ...
## $ acc_open_past_24mths : num [1:100000] 3 2 1 3 8 7 5 5 4 7 ...
## $ avg_cur_bal : num [1:100000] 26033 3526 1701 18134 20495 ...
## $ bc_open_to_buy : num [1:100000] 54787 409 2329 500 2500 ...
## $ bc_util : num [1:100000] 43.2 41.6 82.9 76 54 ...
## $ chargeoff_within_12_mths : num [1:100000] 0 0 0 0 0 0 0 0 0 0 ...
## $ delinq_amnt : num [1:100000] 0 0 0 0 0 0 0 0 0 0 ...
## $ mo_sin_old_il_acct : num [1:100000] 194 127 128 128 156 107 31 146 195 154 ...
## $ mo_sin_old_rev_tl_op : num [1:100000] 245 326 315 361 177 108 97 175 229 150 ...
## $ mo_sin_rcnt_rev_tl_op : num [1:100000] 16 9 39 13 4 2 1 14 8 11 ...
## $ mo_sin_rcnt_tl : num [1:100000] 16 9 20 13 4 2 1 4 8 11 ...
## $ mort_acc : num [1:100000] 7 1 3 2 3 3 0 7 1 1 ...
## $ mths_since_recent_bc : num [1:100000] 16 25 47 43 13 8 45 14 34 11 ...
## $ mths_since_recent_bc_dlq : num [1:100000] 39 43 31 39 39 39 39 39 39 39 ...
## $ mths_since_recent_inq : num [1:100000] 15 9 5 13 7 7 16 5 8 19 ...
## $ mths_since_recent_revol_delinq: num [1:100000] 33 43 31 33 33 33 33 15 33 33 ...
## $ num_accts_ever_120_pd : num [1:100000] 0 2 0 1 0 0 0 0 6 0 ...
## $ num_actv_bc_tl : num [1:100000] 5 2 4 1 1 2 2 4 4 3 ...
## $ num_actv_rev_tl : num [1:100000] 7 3 6 3 6 5 3 4 8 4 ...
## $ num_bc_sats : num [1:100000] 10 2 4 1 3 2 2 6 4 3 ...
## $ num_bc_tl : num [1:100000] 11 6 6 3 6 11 3 11 8 6 ...
## $ num_il_tl : num [1:100000] 7 4 0 3 4 9 3 15 15 4 ...
## $ num_op_rev_tl : num [1:100000] 14 4 7 3 6 10 5 8 11 4 ...
## $ num_rev_accts : num [1:100000] 17 9 15 8 23 21 6 13 19 8 ...
## $ num_rev_tl_bal_gt_0 : num [1:100000] 7 3 6 2 6 5 3 4 8 4 ...
## $ num_sats : num [1:100000] 16 6 7 4 8 12 7 11 14 6 ...
## $ num_tl_120dpd_2m : num [1:100000] 0 0 0 0 0 0 0 0 0 0 ...
## $ num_tl_30dpd : num [1:100000] 0 0 0 0 0 0 0 0 0 0 ...
## $ num_tl_90g_dpd_24m : num [1:100000] 0 0 0 3 0 0 0 0 6 0 ...
## $ num_tl_op_past_12m : num [1:100000] 0 1 0 0 6 4 2 1 2 1 ...
## $ pct_tl_nvr_dlq : num [1:100000] 100 85.7 94.4 54 63 100 100 97 82 100 ...
## $ percent_bc_gt_75 : num [1:100000] 22.2 50 75 100 0 100 100 66.7 100 100 ...
## $ pub_rec_bankruptcies : num [1:100000] 0 0 0 1 1 0 0 0 0 0 ...
## $ tax_liens : num [1:100000] 0 0 0 0 0 0 0 0 0 1 ...
## $ tot_hi_cred_lim : num [1:100000] 457375 33161 21400 85964 171142 ...
## $ total_bal_ex_mort : num [1:100000] 94529 21157 11907 2797 8345 ...
## $ total_bc_limit : num [1:100000] 94900 700 13600 500 2500 13000 5600 23000 23700 19
## $ total_il_high_credit_limit : num [1:100000] 33575 30661 0 0 0 ...
## $ actual_term : num [1:100000] 1.17 1.92 3 1.42 2.59 ...

```

```

## $ actual_return : num [1:100000] 4.39 9.84 8.2 12.78 7.8 ...
## $ propSatisBankcardAccts : num [1:100000] 0.909 0.333 0.667 0.333 0.5 ...
## $ borrHistory : num [1:100000] 20.4 27.2 26.3 30.1 14.7 ...
## $ openAccRatio : num [1:100000] 0.516 0.429 0.389 0.385 0.3 ...

#Findings : There are 69 fields with 100000 rows in train dataset

#summary
summary(df_final)

##      loan_amnt      int_rate      installment      grade      sub_grade
##  Min.    : 1000  Min.    : 5.32  Min.    : 30.12  A:22588  B3     : 7193
##  1st Qu.: 7000  1st Qu.: 8.90  1st Qu.: 227.60  B:33907  B4     : 7103
##  Median  :10000  Median  :11.99  Median  : 347.74  C:26645  B2     : 6880
##  Mean    :12736  Mean    :12.01  Mean    : 421.77  D:12493  A5     : 6539
##  3rd Qu.:17000  3rd Qu.:14.47  3rd Qu.: 557.94  E: 3579  C1     : 6506
##  Max.    :35000  Max.    :28.99  Max.    :1407.01  F:  708   B5     : 6503
##                                         G:    80   (Other):59276
##      home_ownership      annual_inc      verification_status
##  MORTGAGE:46988  Min.    : 3600  Not Verified   :33202
##  OWN       :10437  1st Qu.: 43000  Source Verified:36628
##  RENT      :42575  Median  : 60600  Verified     :30170
##                                         Mean    : 73356
##                                         3rd Qu.: 89000
##                                         Max.   :8500021
##
##      loan_status      pymnt_plan      purpose      addr_state
##  Charged Off:13785  n:100000  debt_consolidation:57622  CA     :15001
##  Fully Paid :86215           credit_card      :24989  NY     : 8518
##                                         home_improvement : 5654  TX     : 8260
##                                         other          : 5091  FL     : 7055
##                                         major_purchase  : 1823  IL     : 4071
##                                         medical        : 1119  NJ     : 3575
##                                         (Other)        : 3702  (Other):53520
##      dti      delinq_2yrs      earliest_cr_line
##  Min.    : 0.00  Min.    : 0.0000  Min.   :1949-06-01 00:00:00.000
##  1st Qu.:11.63  1st Qu.: 0.0000  1st Qu.:1994-08-01 00:00:00.000
##  Median  :17.34  Median  : 0.0000  Median  :1999-12-01 00:00:00.000
##  Mean    :17.91  Mean    : 0.3341  Mean    :1998-06-11 17:59:53.088
##  3rd Qu.:23.81  3rd Qu.: 0.0000  3rd Qu.:2003-10-01 00:00:00.000
##  Max.    :71.40  Max.    :21.0000  Max.   :2012-11-01 00:00:00.000
##
##      inq_last_6mths  mths_since_last_delinq  mths_since_last_record  open_acc
##  Min.    :0.000  Min.    : 0.00  Min.    : 0.0  Min.    : 0.00
##  1st Qu.:0.000  1st Qu.: 30.00  1st Qu.: 69.0  1st Qu.: 8.00
##  Median :0.000  Median  : 31.00  Median  : 69.0  Median  :10.00
##  Mean    :0.669  Mean    : 32.47  Mean    : 69.1  Mean    :11.42
##  3rd Qu.:1.000  3rd Qu.: 31.00  3rd Qu.: 69.0  3rd Qu.:14.00
##  Max.    :6.000  Max.    :188.00  Max.    :119.0  Max.    :79.00
##
##      pub_rec      revol_bal      revol_util      total_acc
##  Min.    : 0.0000  Min.    : 0  Min.    : 0.00  Min.    : 2.00
##  1st Qu.: 0.0000  1st Qu.: 5896  1st Qu.: 36.20  1st Qu.: 16.00
##  Median : 0.0000  Median  : 10725  Median  : 54.10  Median  : 23.00

```

```

##  Mean   : 0.2267   Mean   : 15795   Mean   : 53.75   Mean   : 24.76
##  3rd Qu.: 0.0000   3rd Qu.: 18913   3rd Qu.: 71.80   3rd Qu.: 32.00
##  Max.   :19.0000   Max.   :924579    Max.   :153.70   Max.   :162.00
##
##  initial_list_status  total_pymnt      last_pymnt_d
##  f:50531              Min.   : 0     Min.   :2013-02-01 00:00:00.00
##  w:49469              1st Qu.: 6936  1st Qu.:2016-01-01 00:00:00.00
##                           Median :11471  Median :2016-12-01 00:00:00.00
##                           Mean   :13790  Mean   :2016-11-10 01:42:09.68
##                           3rd Qu.:18294  3rd Qu.:2017-11-01 00:00:00.00
##                           Max.   :50941  Max.   :2019-02-01 00:00:00.00
##                           NA's   :64
##  collections_12_mths_ex_med mths_since_last_major_derog acc_now_delinq
##  Min.   :0.0000          Min.   : 0     Min.   :0.00000
##  1st Qu.:0.0000          1st Qu.: 43    1st Qu.:0.00000
##  Median :0.0000          Median : 43    Median :0.00000
##  Mean   :0.0167          Mean   : 43    Mean   :0.00577
##  3rd Qu.:0.0000          3rd Qu.: 43    3rd Qu.:0.00000
##  Max.   :6.0000          Max.   :188    Max.   :4.00000
##
##  tot_coll_amt      tot_cur_bal      total_rev_hi_lim  acc_open_past_24mths
##  Min.   : 0.0  Min.   : 0     Min.   : 0     Min.   : 0.000
##  1st Qu.: 0.0  1st Qu.: 25656  1st Qu.: 12800  1st Qu.: 2.000
##  Median : 0.0  Median : 65143  Median : 22000  Median : 4.000
##  Mean   : 232.8  Mean   : 128759  Mean   : 30545  Mean   : 4.396
##  3rd Qu.: 0.0  3rd Qu.: 191246  3rd Qu.: 37500  3rd Qu.: 6.000
##  Max.   :262740.0  Max.   :3292113  Max.   :1165700  Max.   :42.000
##
##  avg_cur_bal      bc_open_to_buy      bc_util      chargeoff_within_12_mths
##  Min.   : 0     Min.   : 0     Min.   : 0.00  Min.   :0.00000
##  1st Qu.: 2791  1st Qu.: 1224  1st Qu.: 42.70  1st Qu.:0.00000
##  Median : 6312  Median : 3893  Median : 66.20  Median :0.00000
##  Mean   : 12470  Mean   : 8997  Mean   : 62.49  Mean   :0.01015
##  3rd Qu.: 17266 3rd Qu.: 10491 3rd Qu.: 86.00  3rd Qu.:0.00000
##  Max.   :395953  Max.   :332178  Max.   :188.80  Max.   :6.00000
##
##  delinq_amnt      mo_sin_old_il_acct mo_sin_old_rev_tl_op
##  Min.   : 0.00  Min.   : 0.0     Min.   : 3.0
##  1st Qu.: 0.00  1st Qu.: 97.0   1st Qu.:115.0
##  Median : 0.00  Median :128.0   Median :164.0
##  Mean   : 12.44  Mean   :125.1   Mean   :182.4
##  3rd Qu.: 0.00  3rd Qu.:151.0   3rd Qu.:231.0
##  Max.   :88216.00  Max.   :640.0   Max.   :780.0
##
##  mo_sin_rcnt_rev_tl_op mo_sin_rcnt_tl      mort_acc      mths_since_recent_bc
##  Min.   : 0.00  Min.   : 0.000  Min.   : 0.000  Min.   : 0.0
##  1st Qu.: 4.00  1st Qu.: 3.000  1st Qu.: 0.000  1st Qu.: 6.0
##  Median : 8.00  Median : 6.000  Median : 1.000  Median : 14.0
##  Mean   : 13.25  Mean   : 8.231  Mean   : 1.635  Mean   : 24.4
##  3rd Qu.: 16.00  3rd Qu.:10.000  3rd Qu.: 3.000  3rd Qu.: 29.0
##  Max.   :293.00  Max.   :226.000  Max.   :25.000  Max.   :616.0
##
##  mths_since_recent_bc_dlq mths_since_recent_inq mths_since_recent_revol_delinq
##  Min.   : 0.00  Min.   : 0.000  Min.   : 0.00

```

```

## 1st Qu.: 39.00          1st Qu.: 2.000          1st Qu.: 33.00
## Median : 39.00          Median : 5.000          Median : 33.00
## Mean   : 39.25          Mean   : 6.706          Mean   : 34.01
## 3rd Qu.: 39.00          3rd Qu.:10.000         3rd Qu.: 33.00
## Max.   :176.00          Max.   :24.000          Max.   :176.00
##
## num_accts_ever_120_pd num_actv_bc_tl  num_actv_rev_tl  num_bc_sats
## Min.   : 0.0000         Min.   : 0.000         Min.   : 0.000         Min.   : 0.000
## 1st Qu.: 0.0000         1st Qu.: 2.000         1st Qu.: 3.000         1st Qu.: 3.000
## Median : 0.0000         Median : 3.000         Median : 5.000         Median : 4.000
## Mean   : 0.4969         Mean   : 3.643         Mean   : 5.673         Mean   : 4.653
## 3rd Qu.: 0.0000         3rd Qu.: 5.000         3rd Qu.: 7.000         3rd Qu.: 6.000
## Max.   :23.0000         Max.   :26.000         Max.   :41.000         Max.   :36.000
##
## num_bc_tl      num_il_tl      num_op_rev_tl  num_rev_accts
## Min.   : 0.000         Min.   : 0.000         Min.   : 0.00         Min.   : 2.00
## 1st Qu.: 5.000         1st Qu.: 3.000         1st Qu.: 5.00         1st Qu.: 9.00
## Median : 7.000         Median : 6.000         Median : 7.00         Median :13.00
## Mean   : 8.297         Mean   : 8.085         Mean   : 8.16         Mean   :14.76
## 3rd Qu.:11.000         3rd Qu.:11.000        3rd Qu.:10.00        3rd Qu.:19.00
## Max.   :61.000         Max.   :132.000        Max.   :67.00         Max.   :87.00
##
## num_rev_tl_bal_gt_0  num_sats      num_tl_120dpd_2m  num_tl_30dpd
## Min.   : 0.000         Min.   : 0.00         Min.   :0.00000         Min.   :0.00000
## 1st Qu.: 3.000         1st Qu.: 8.00         1st Qu.:0.00000       1st Qu.:0.00000
## Median : 5.000         Median :10.00         Median :0.00000       Median :0.00000
## Mean   : 5.633         Mean   :11.37         Mean   :0.00078       Mean   :0.00383
## 3rd Qu.: 7.000         3rd Qu.:14.00         3rd Qu.:0.00000       3rd Qu.:0.00000
## Max.   :36.000         Max.   :79.00         Max.   :2.00000       Max.   :4.00000
##
## num_tl_90g_dpd_24m  num_tl_op_past_12m  pct_tl_nvr_dlq  percent_bc_gt_75
## Min.   : 0.00000         Min.   : 0.000         Min.   : 20.00         Min.   :  0.00
## 1st Qu.: 0.00000         1st Qu.: 1.000         1st Qu.: 91.00         1st Qu.: 16.70
## Median : 0.00000         Median : 2.000         Median : 97.80         Median : 50.00
## Mean   : 0.09251         Mean   : 2.046         Mean   : 94.05         Mean   : 48.05
## 3rd Qu.: 0.00000         3rd Qu.: 3.000         3rd Qu.:100.00        3rd Qu.: 75.00
## Max.   :20.00000         Max.   :26.000         Max.   :100.00        Max.   :100.00
##
## pub_rec_bankruptcies  tax_liens      tot_hi_cred_lim  total_bal_ex_mort
## Min.   :0.0000          Min.   : 0.00000         Min.   :    0          Min.   :    0
## 1st Qu.:0.0000          1st Qu.: 0.00000         1st Qu.: 43247        1st Qu.: 18924
## Median :0.0000          Median : 0.00000         Median : 93904        Median : 34084
## Mean   :0.1376          Mean   : 0.05683         Mean   : 159185       Mean   : 45925
## 3rd Qu.:0.0000          3rd Qu.: 0.00000         3rd Qu.: 229283       3rd Qu.: 57457
## Max.   :8.0000          Max.   :18.00000         Max.   :3647089       Max.   :1067947
##
## total_bc_limit  total_il_high_credit_limit  actual_term  actual_return
## Min.   : 0             Min.   : 0                 Min.   :0.000  Min.   :-33.333
## 1st Qu.: 7000          1st Qu.: 12142            1st Qu.:1.506  1st Qu.: 4.392
## Median : 13600          Median : 28353            Median :2.672  Median : 6.804
## Mean   : 20178          Mean   : 38086            Mean   :2.249  Mean   : 5.266
## 3rd Qu.: 26000          3rd Qu.: 51262            3rd Qu.:3.001  3rd Qu.: 9.454
## Max.   :332200          Max.   :1027358           Max.   :3.923  Max.   : 44.359
##

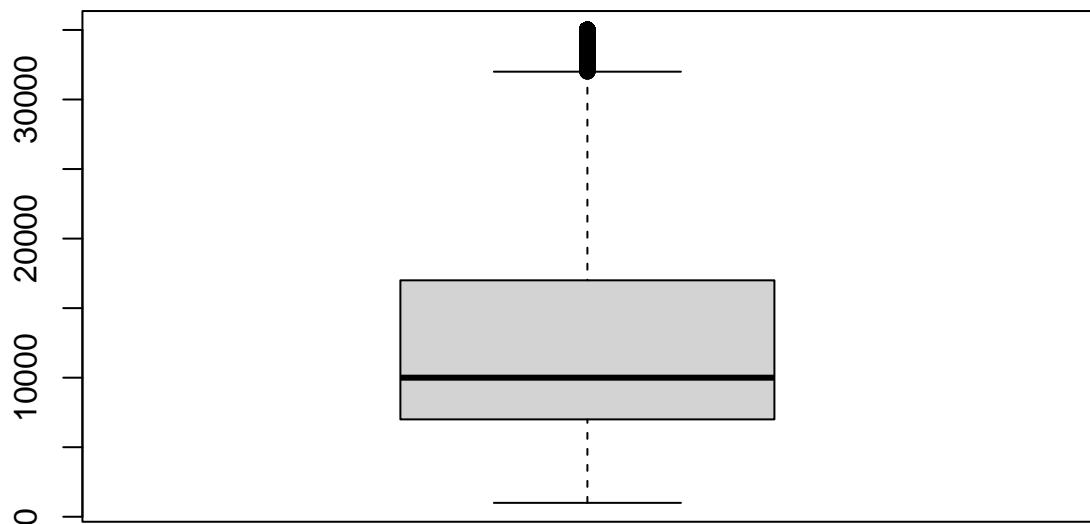
```

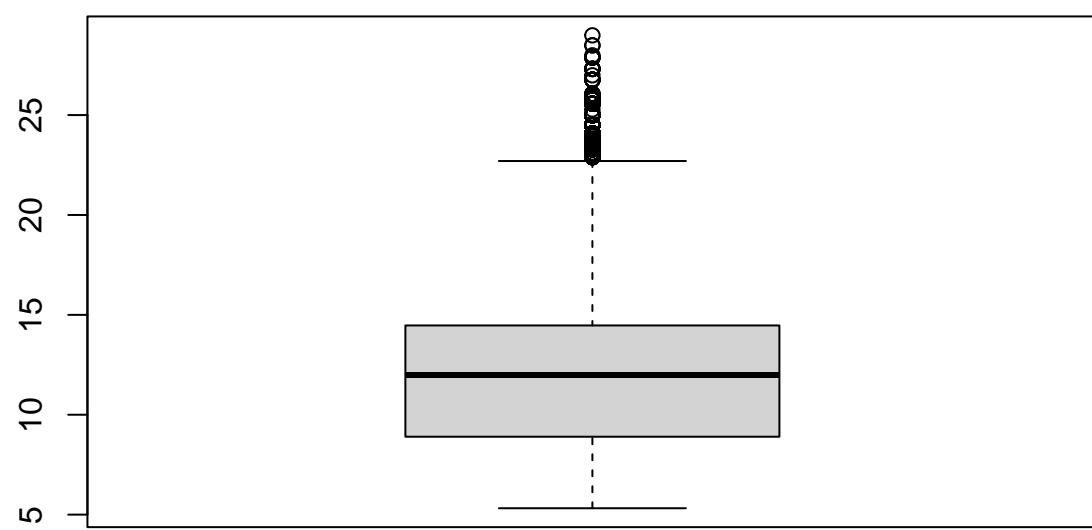
```

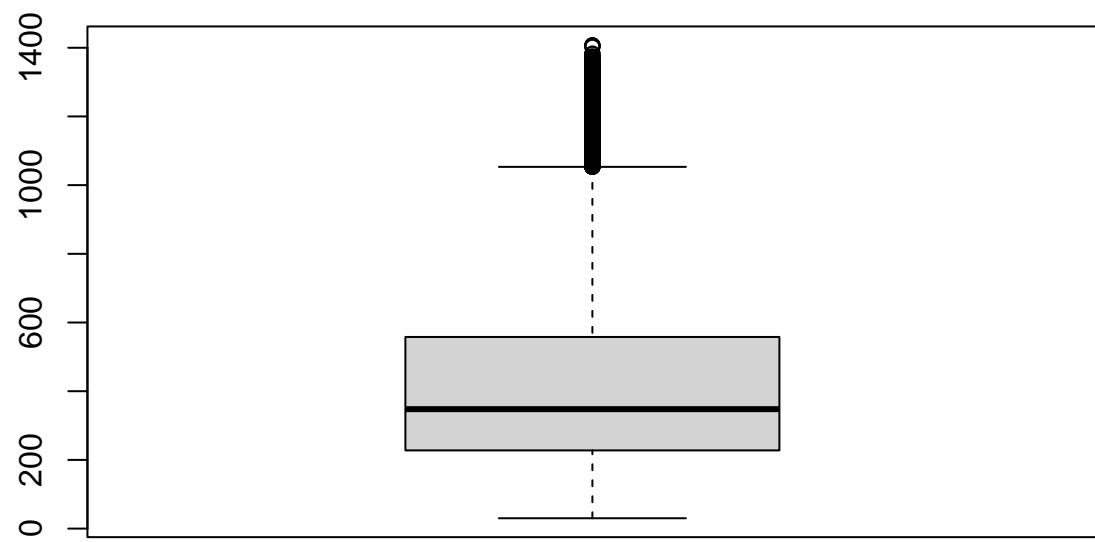
##  propSatisBankcardAccts  borrHistory      openAccRatio
##  Min.   :0.0000          Min.   : 3.001  Min.   :0.0000
##  1st Qu.:0.4286          1st Qu.:11.165 1st Qu.:0.3704
##  Median :0.6000          Median :14.831  Median :0.4800
##  Mean    :0.6161          Mean   :16.382  Mean   :0.5014
##  3rd Qu.:0.8000          3rd Qu.:20.246 3rd Qu.:0.6154
##  Max.    :1.0000          Max.   :64.999  Max.   :1.0000
## 

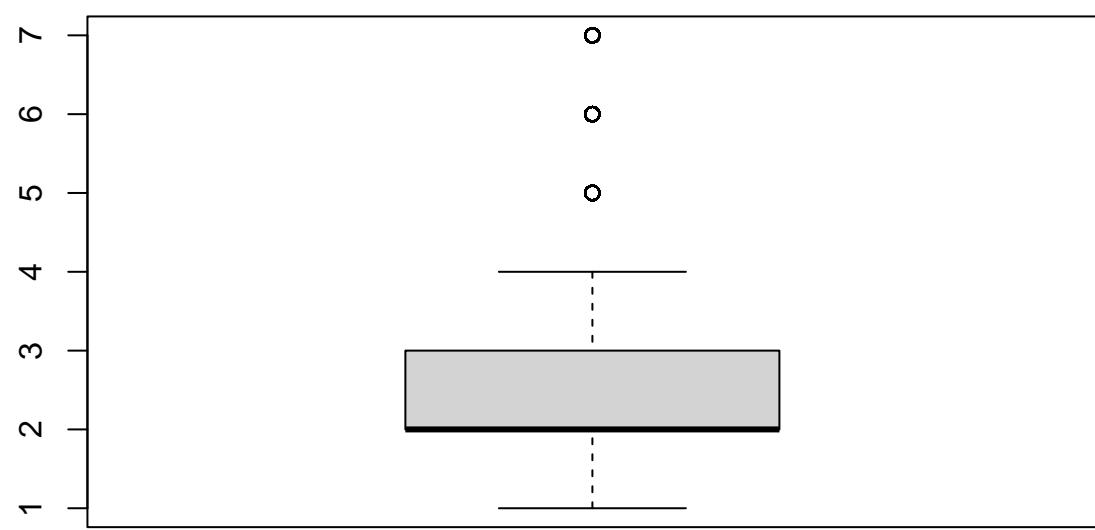
# Boxplot for all the variables
#par(mfrow = c(1, ncol(df_final)), mar=c(1,1,1,1))
invisible(lapply(1:ncol(df_final), function(i) boxplot(df_final[, i])))

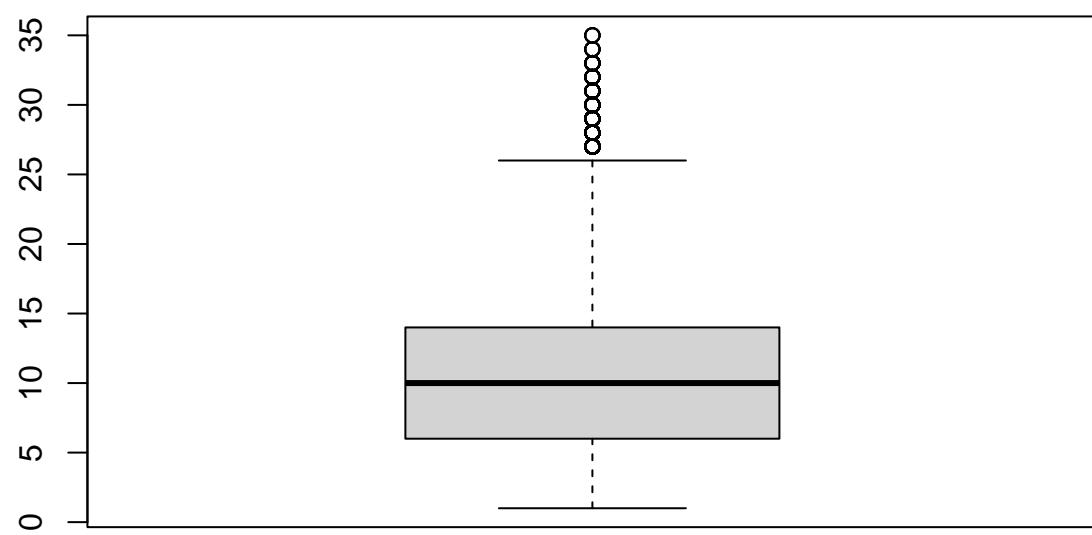
```

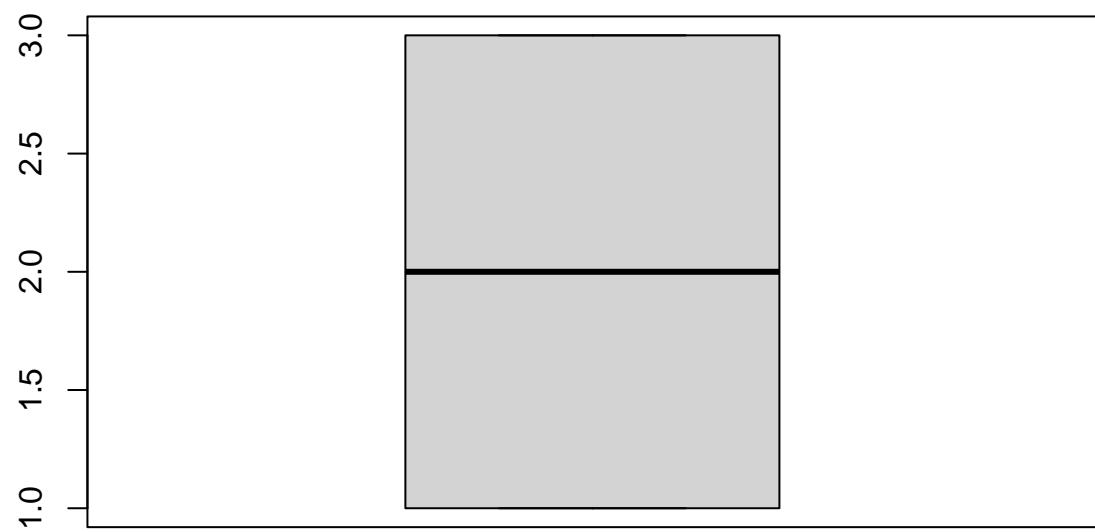


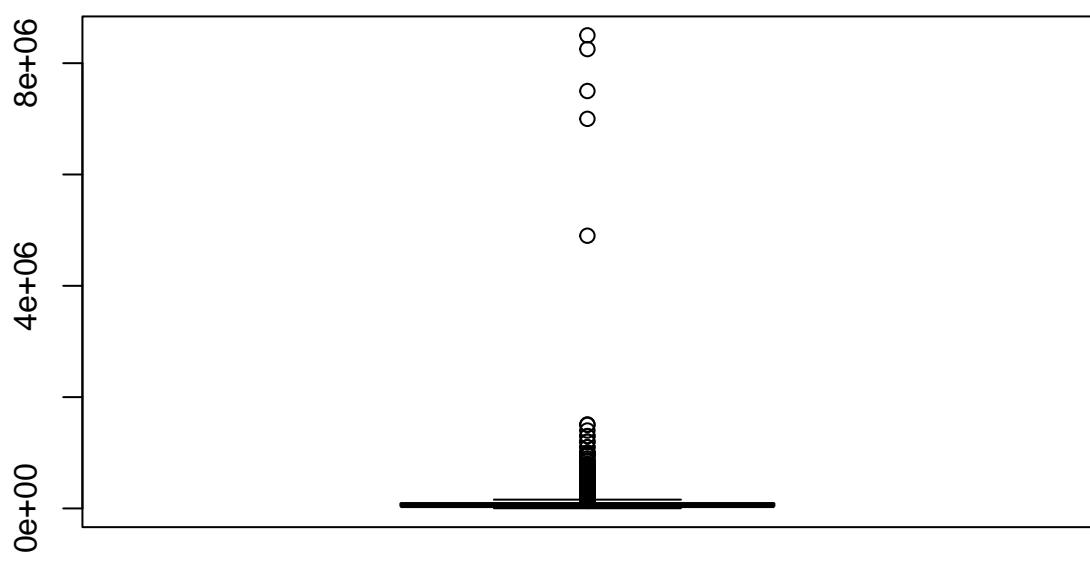


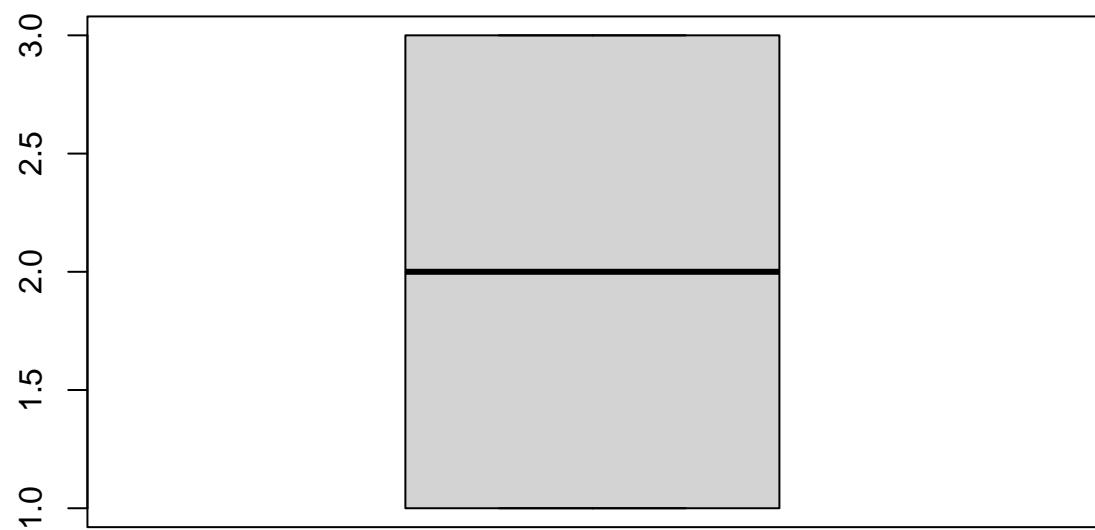


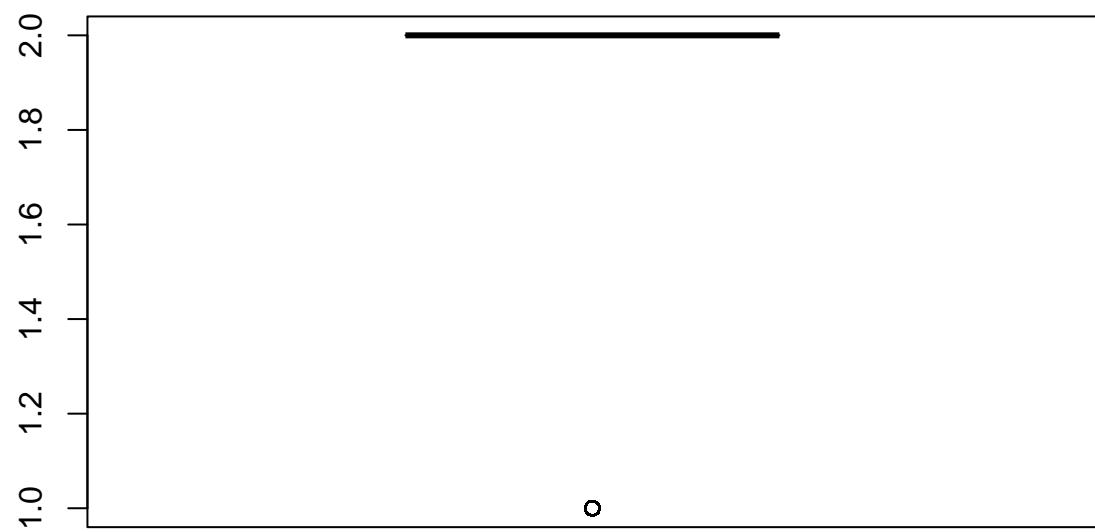


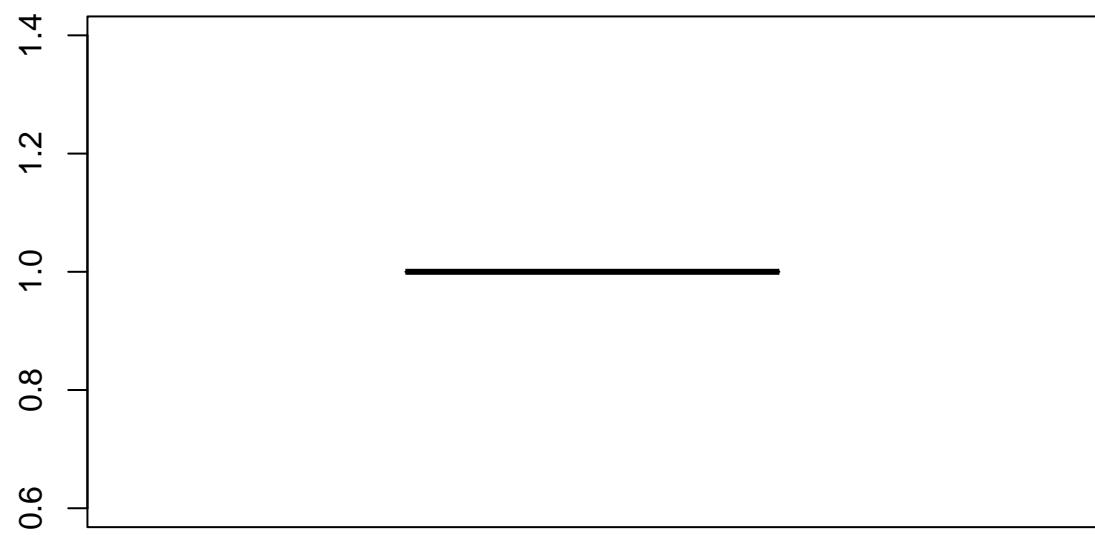


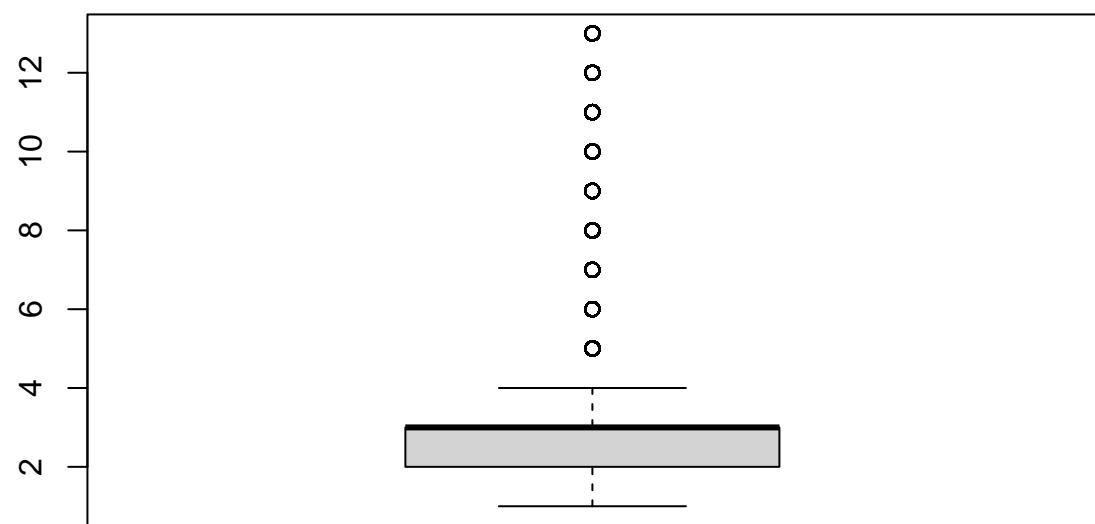


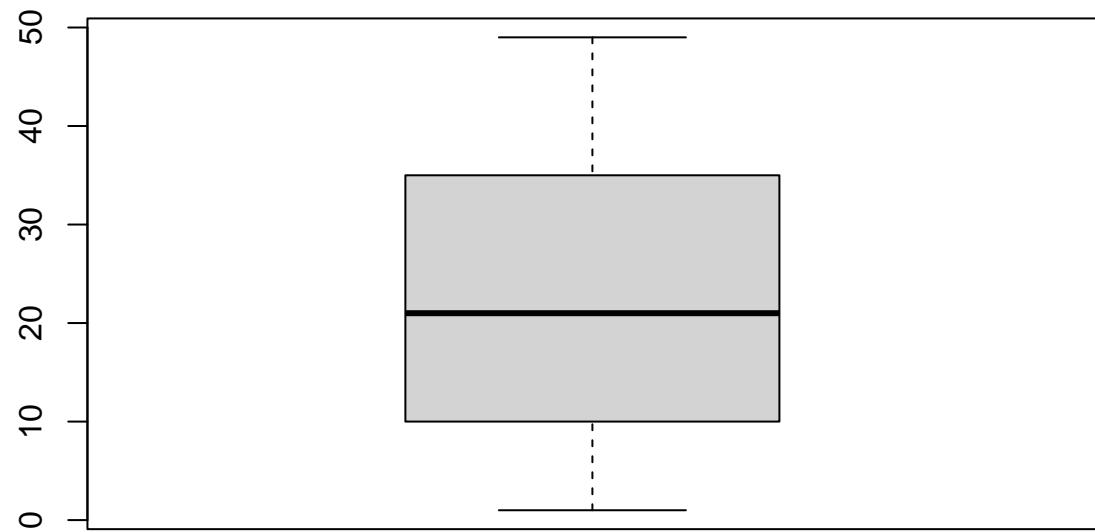


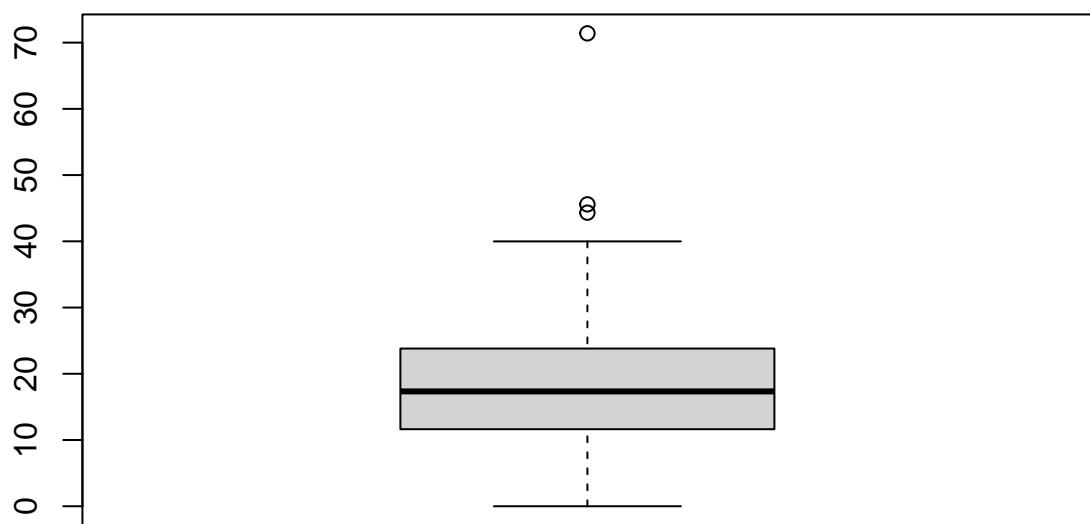


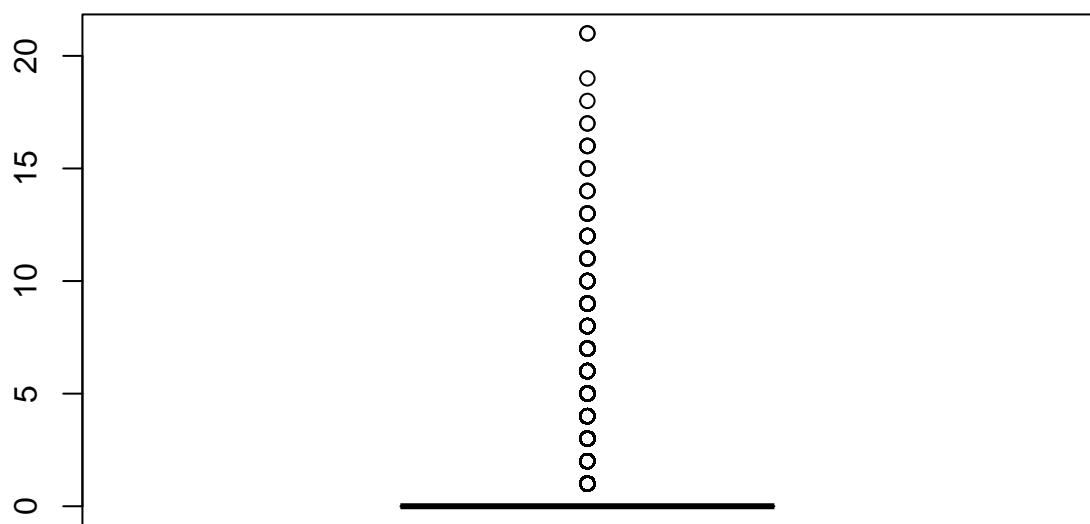


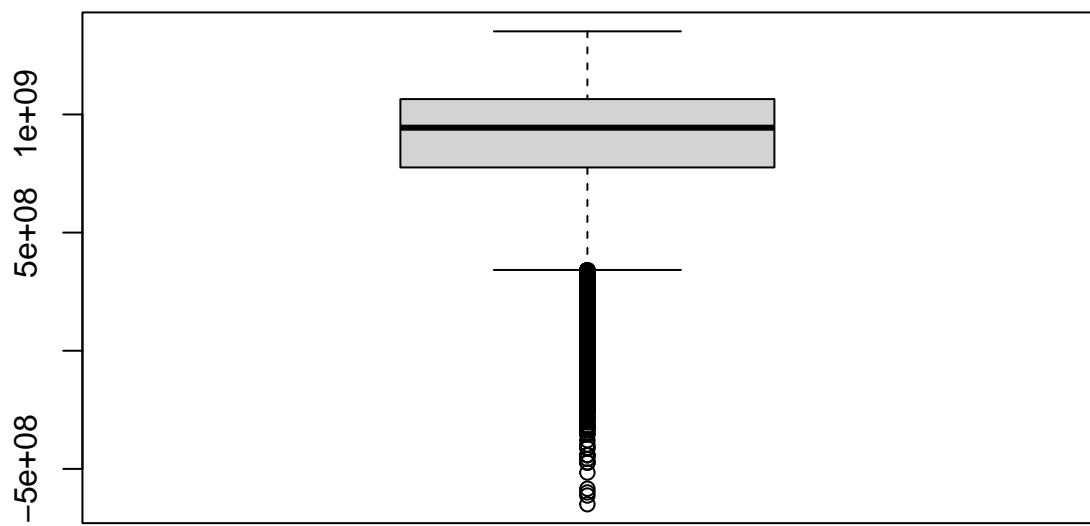


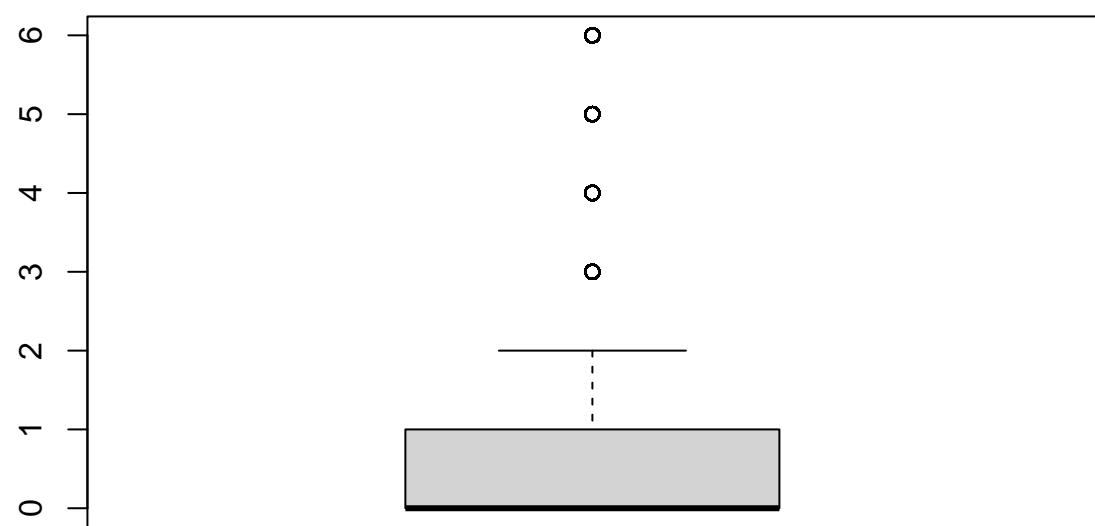


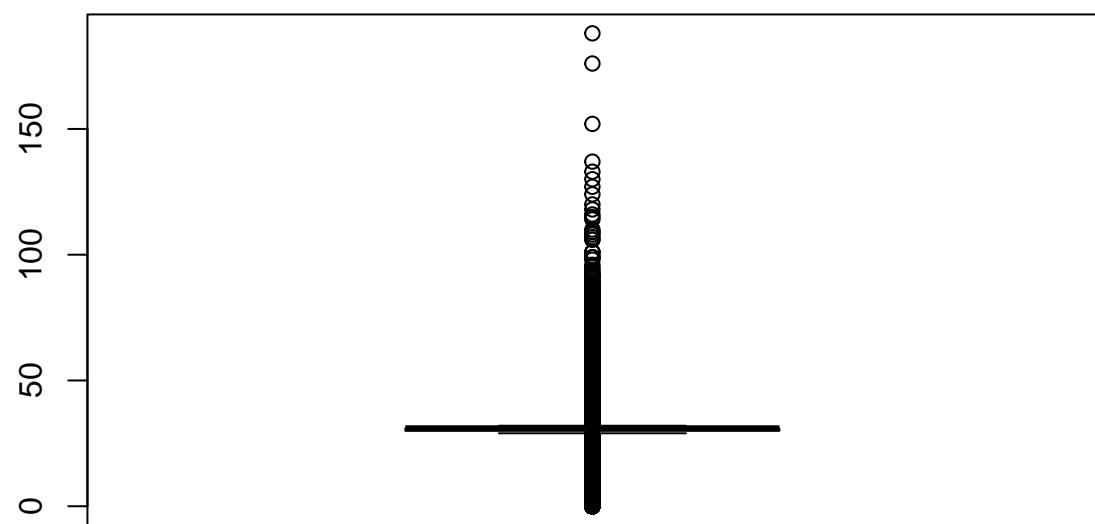


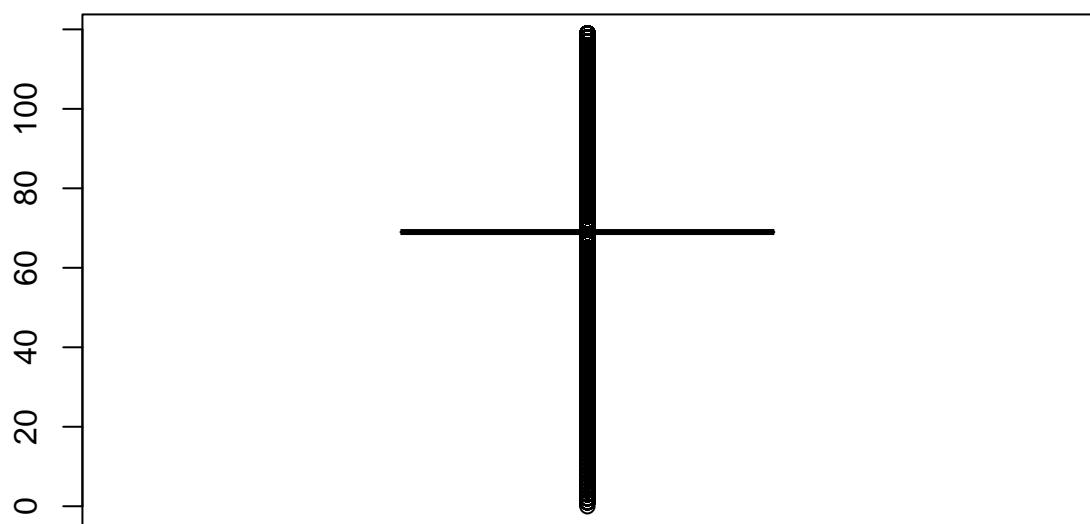


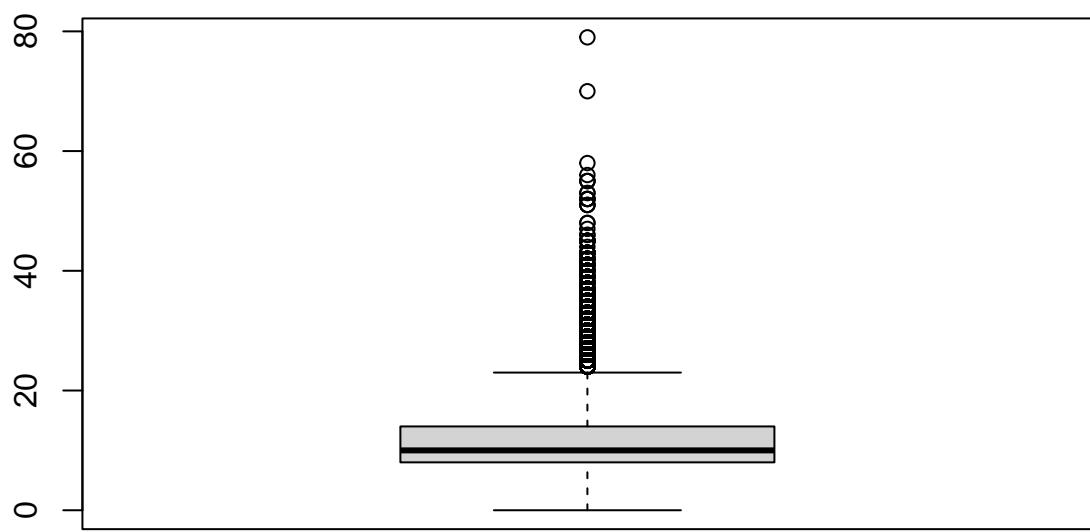


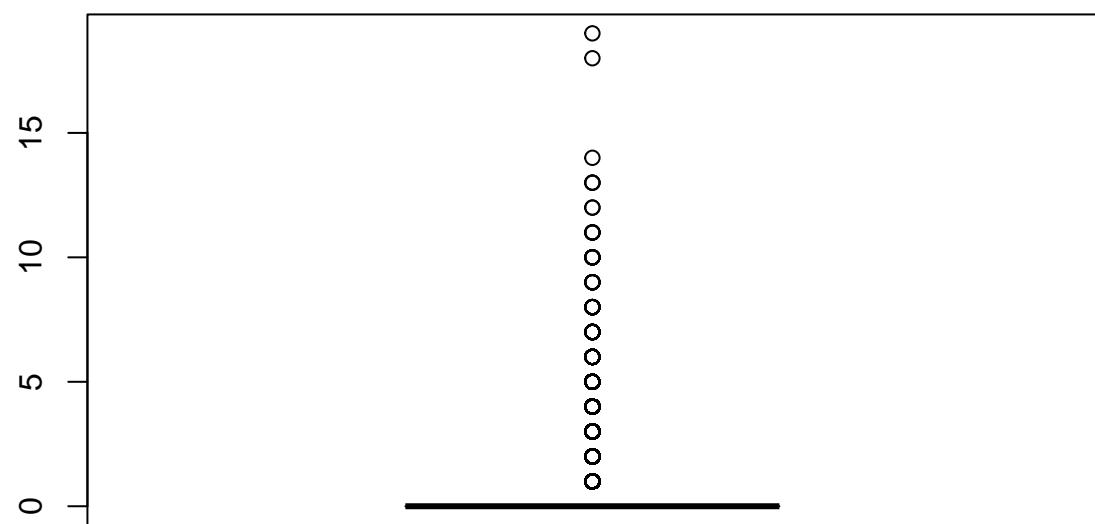


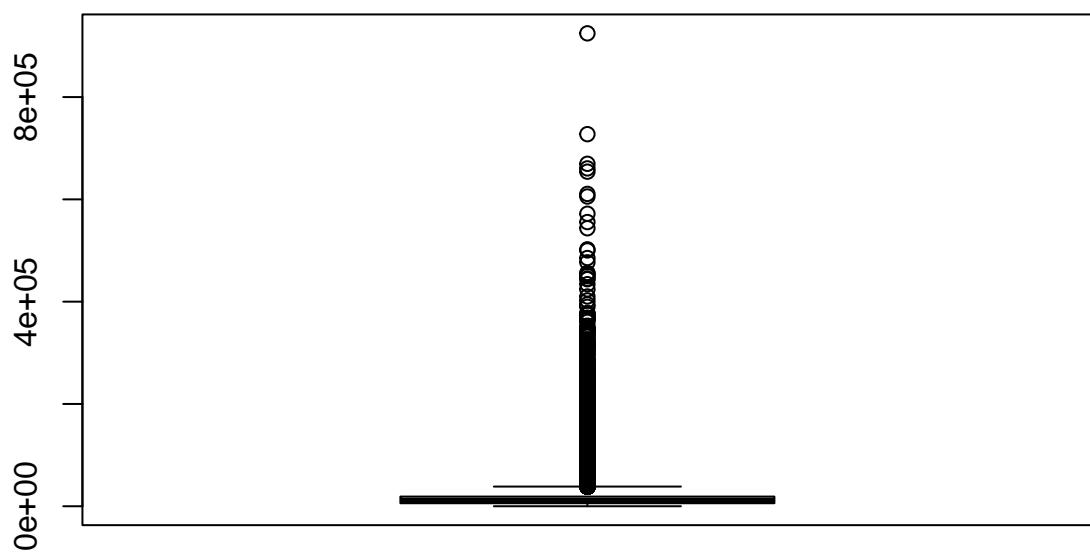


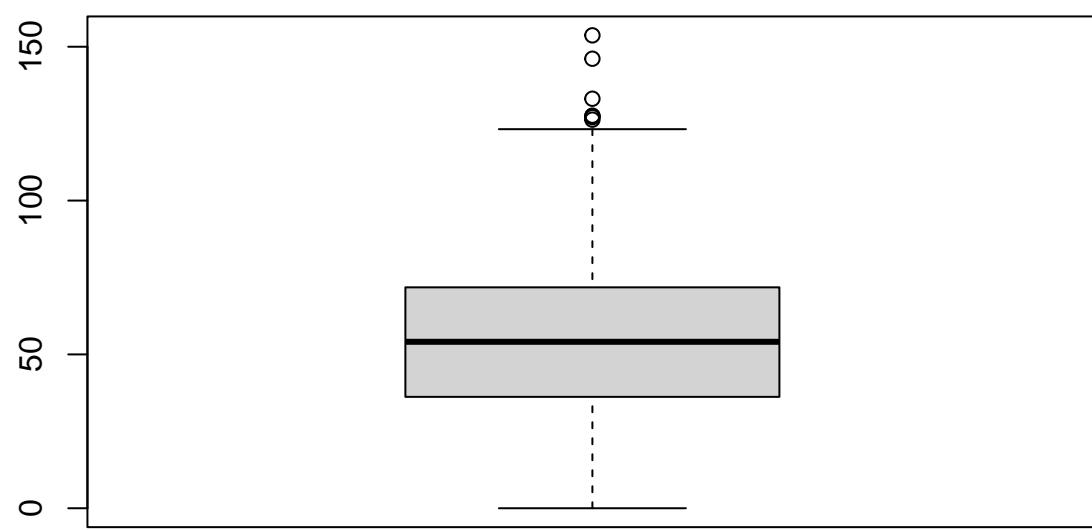


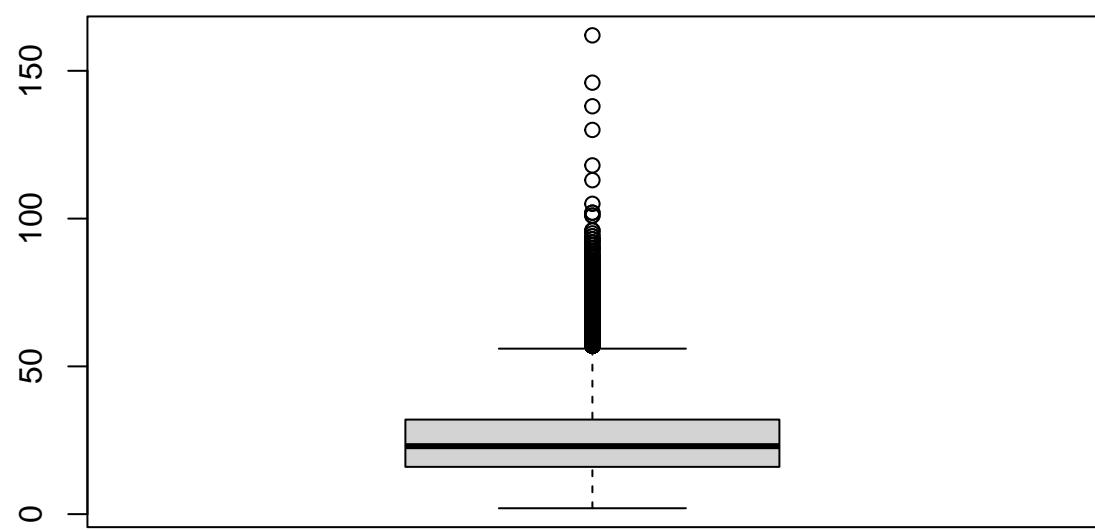


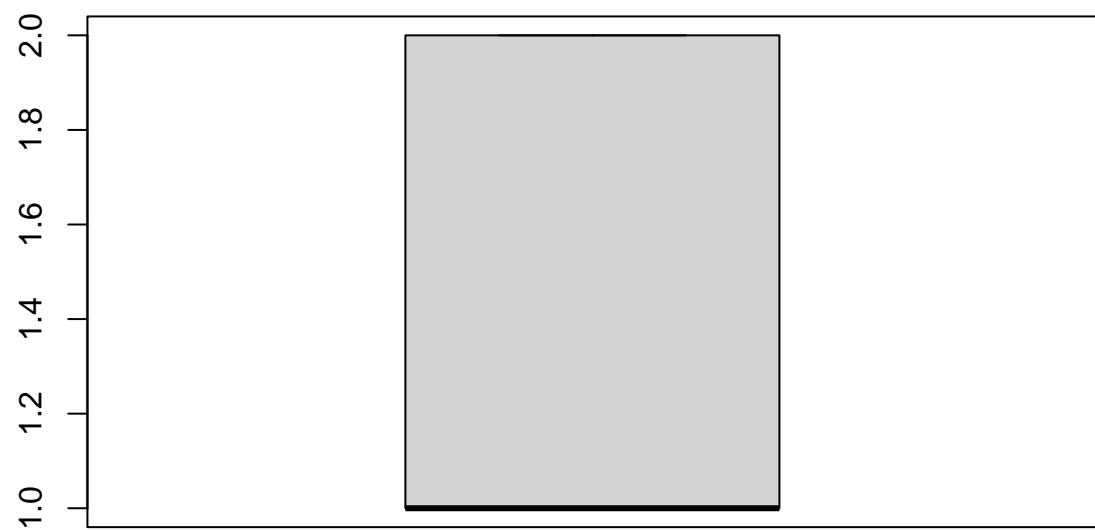


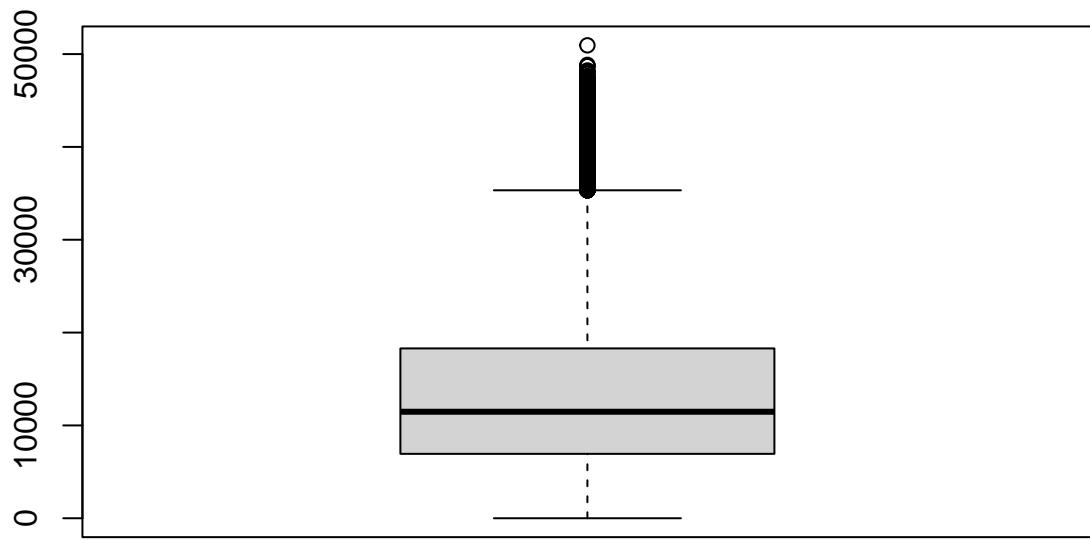


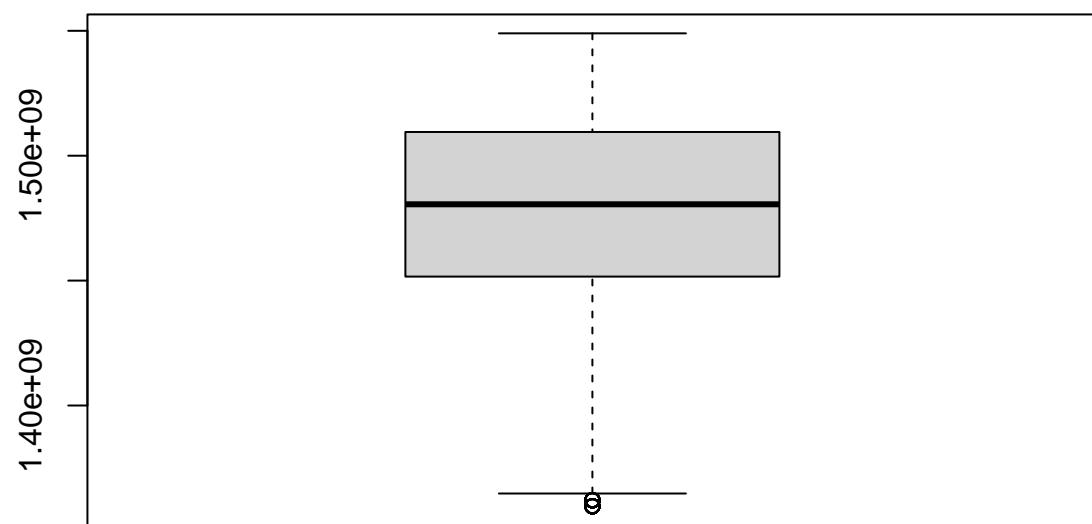


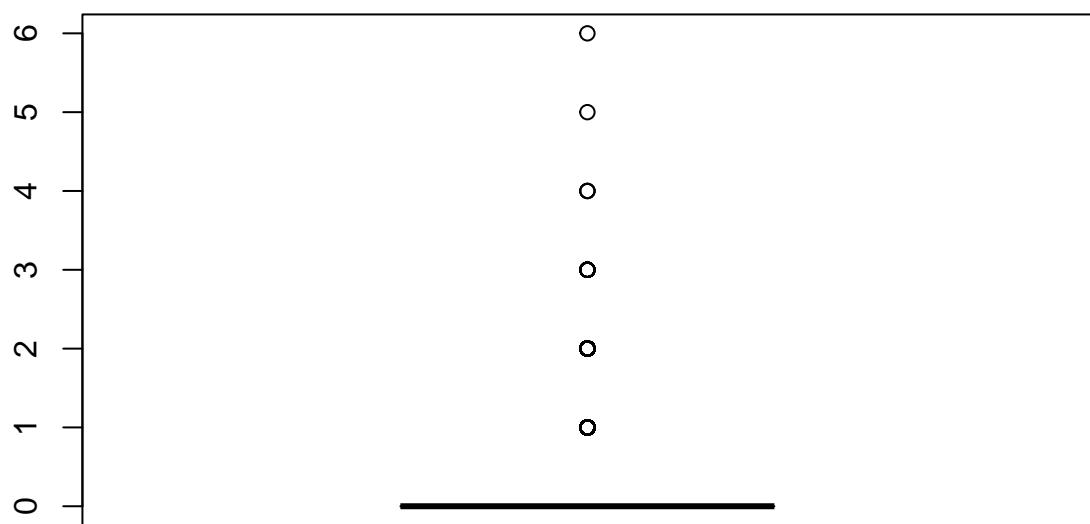


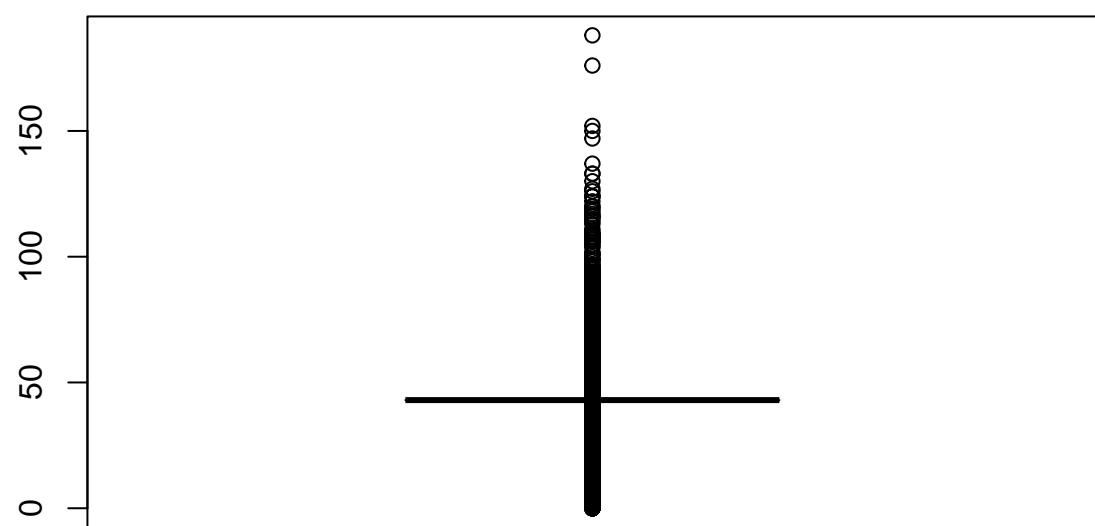


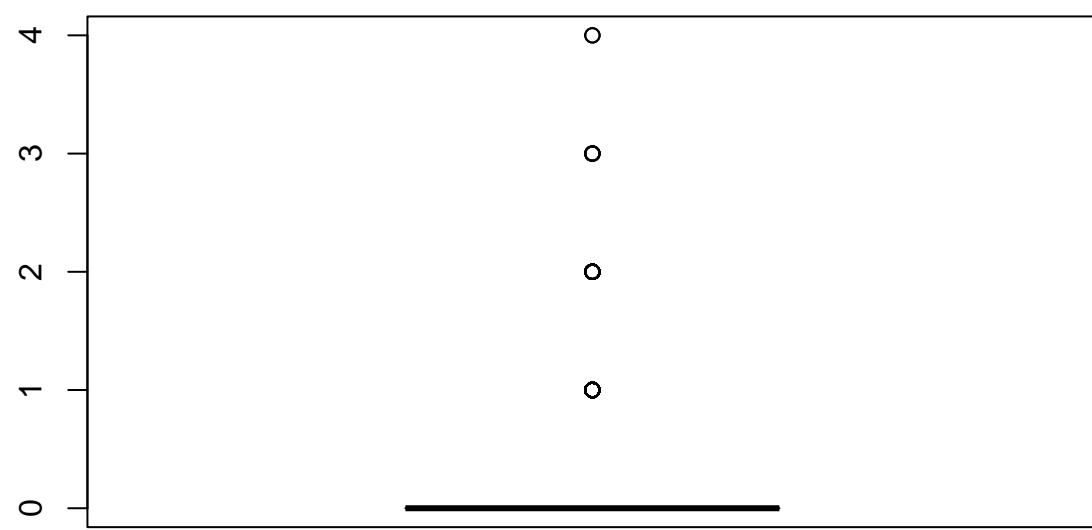


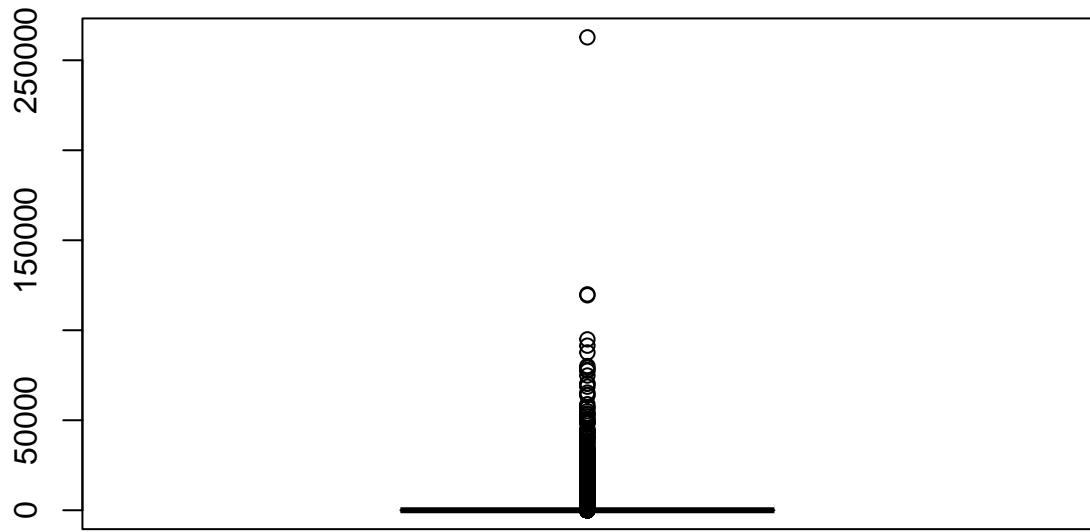


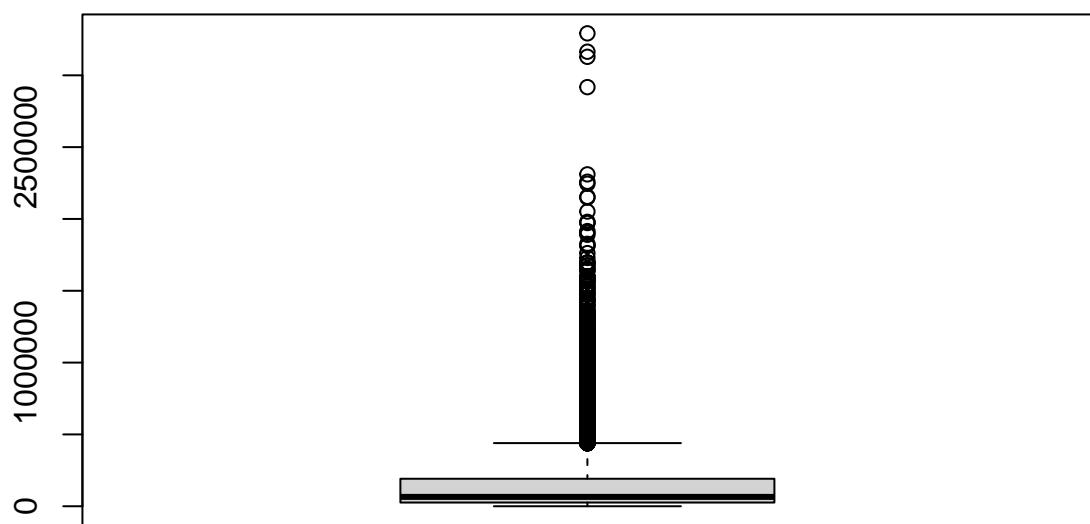


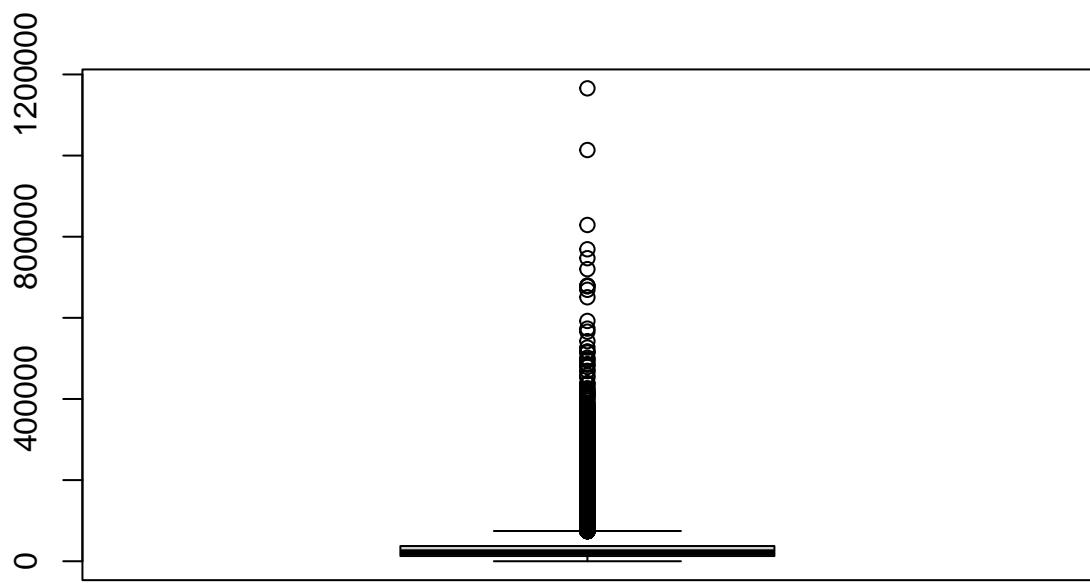


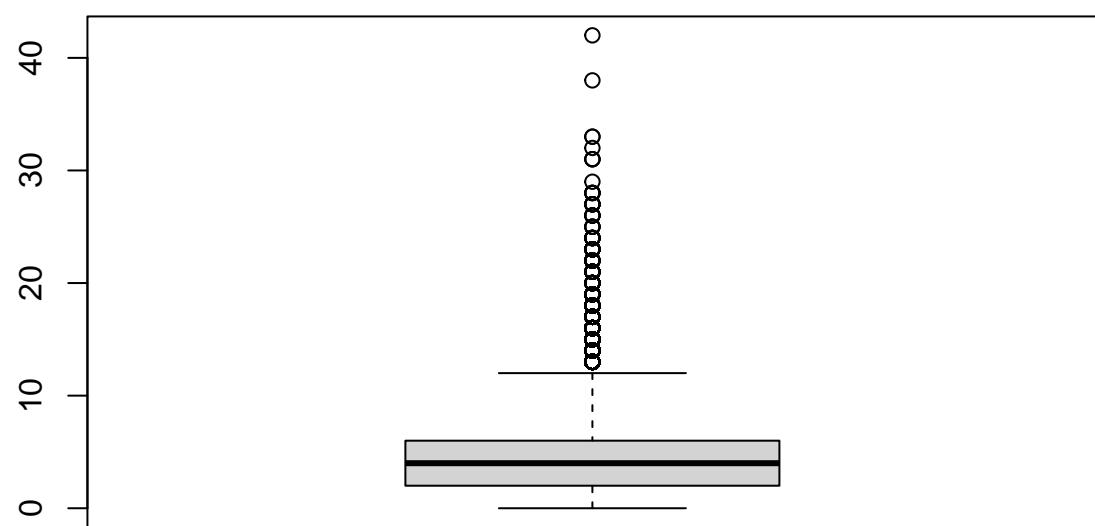


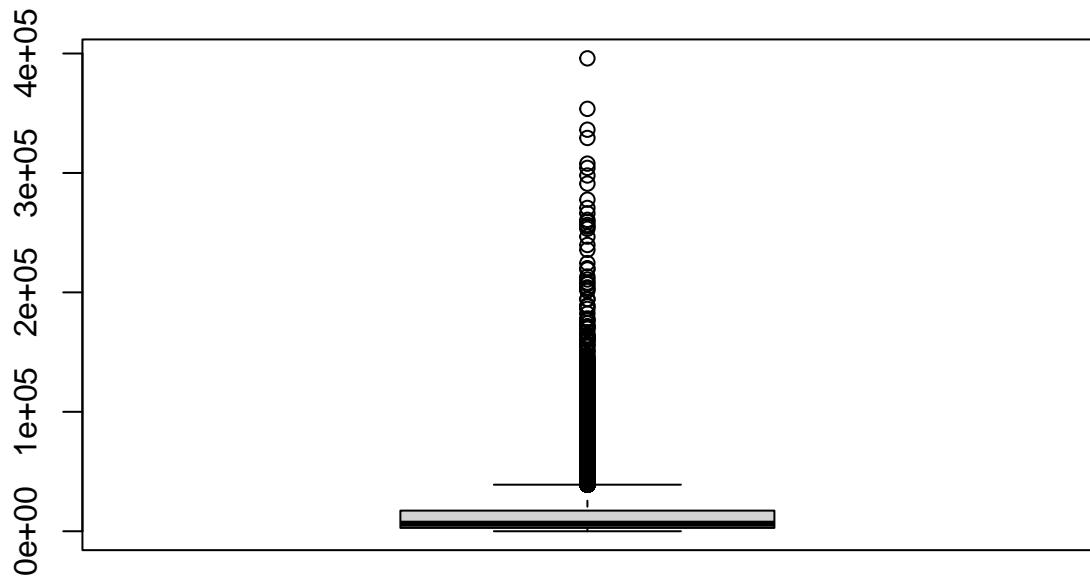


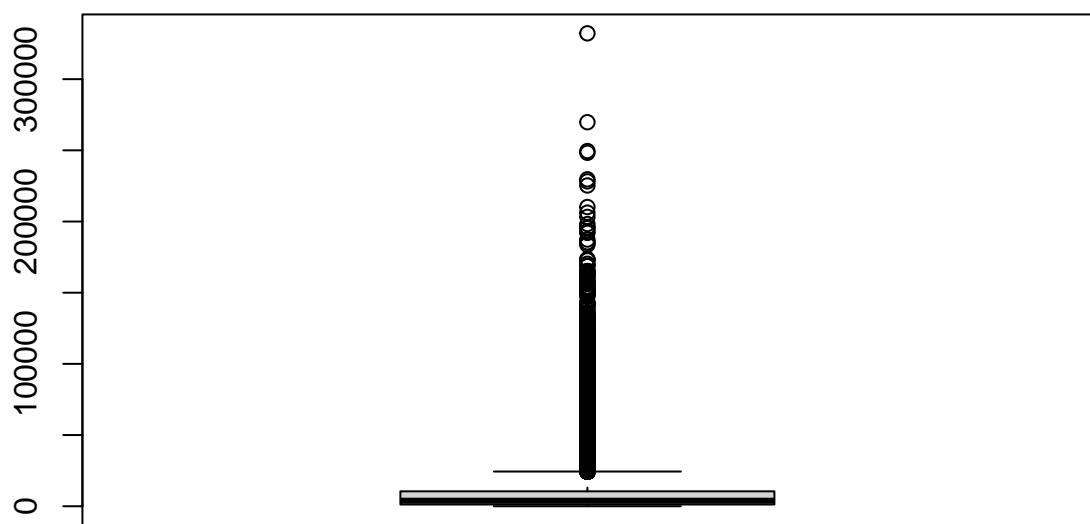


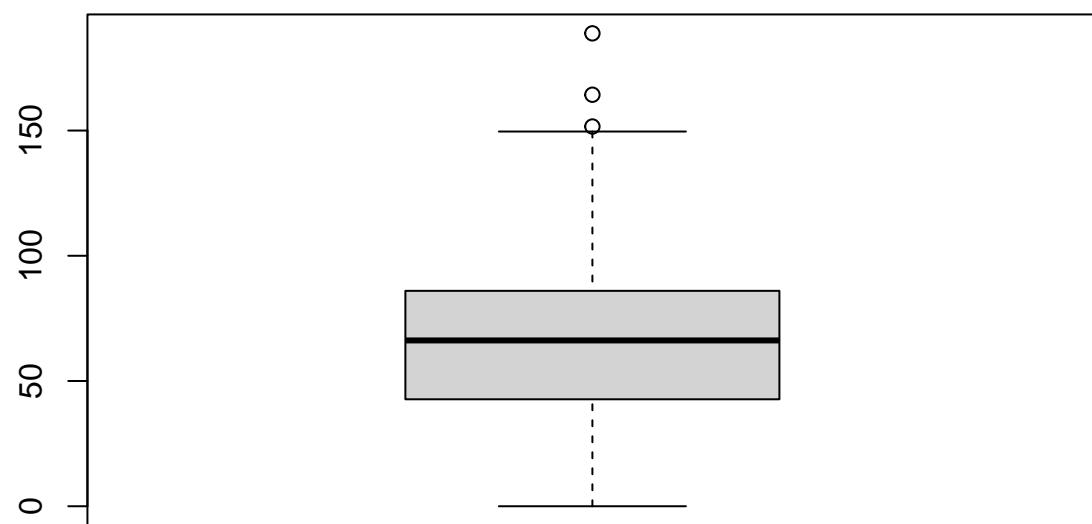


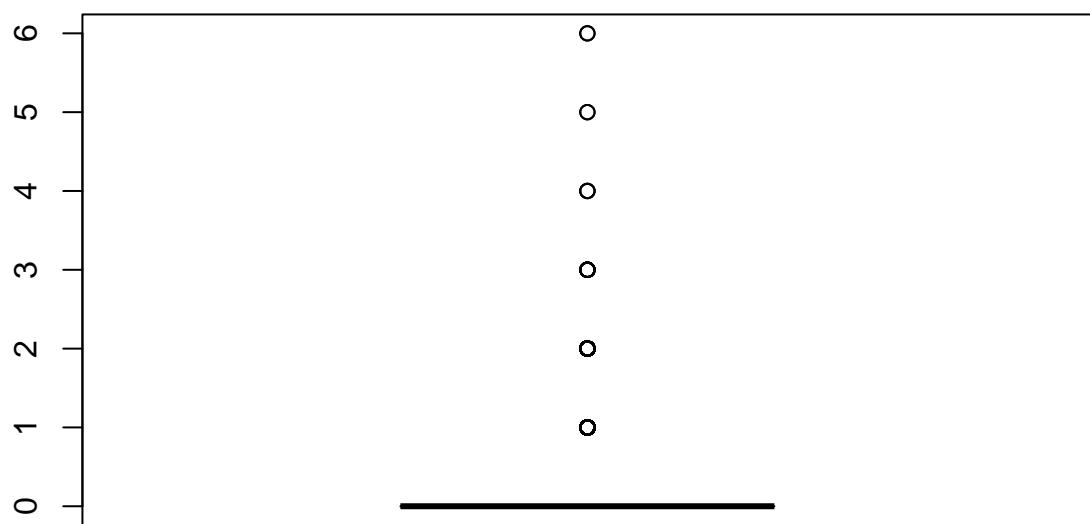


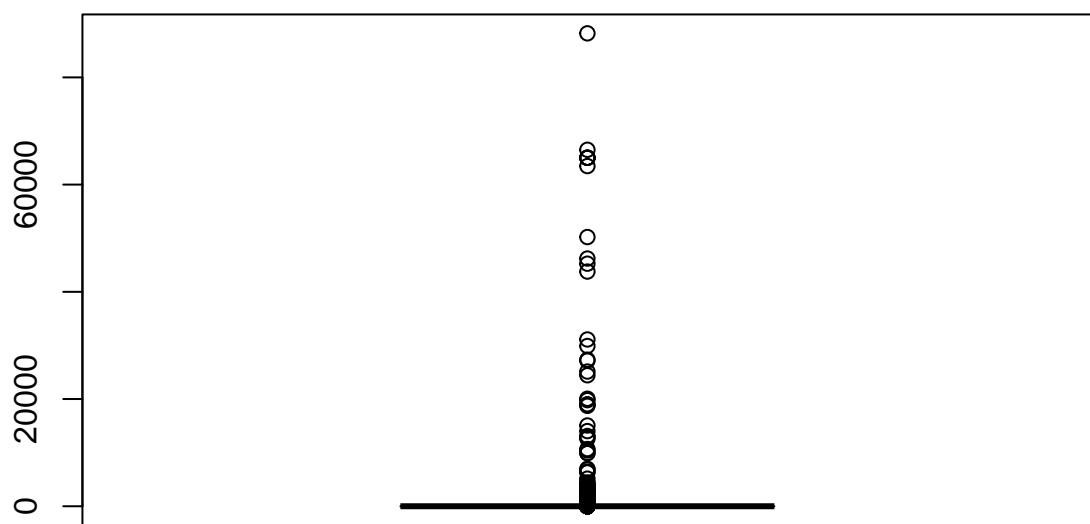


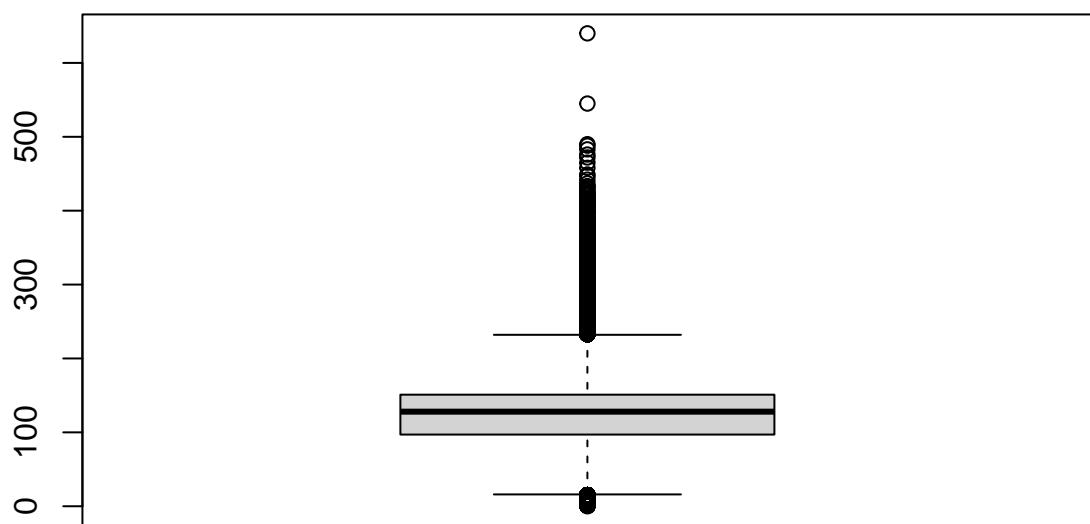


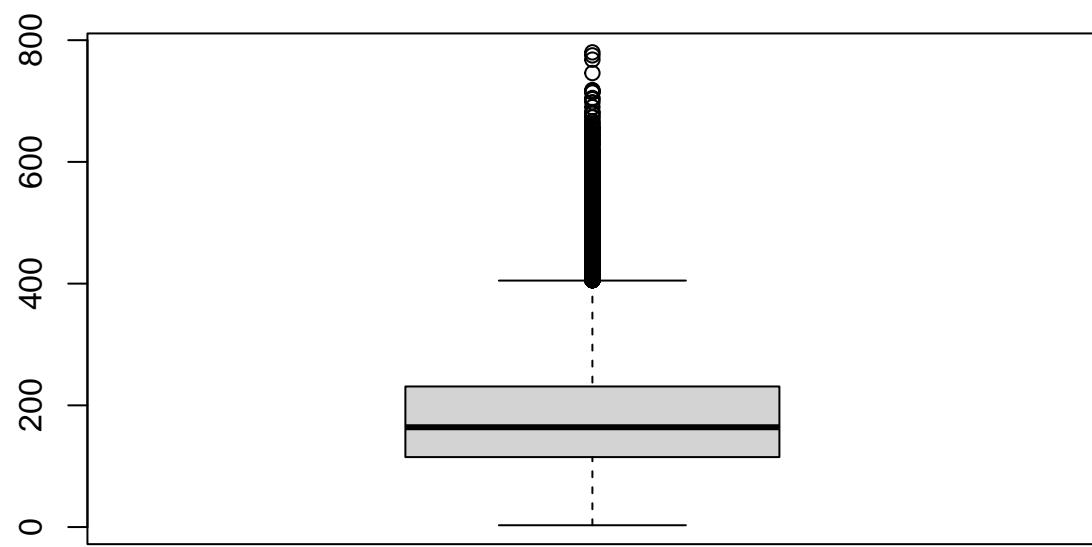


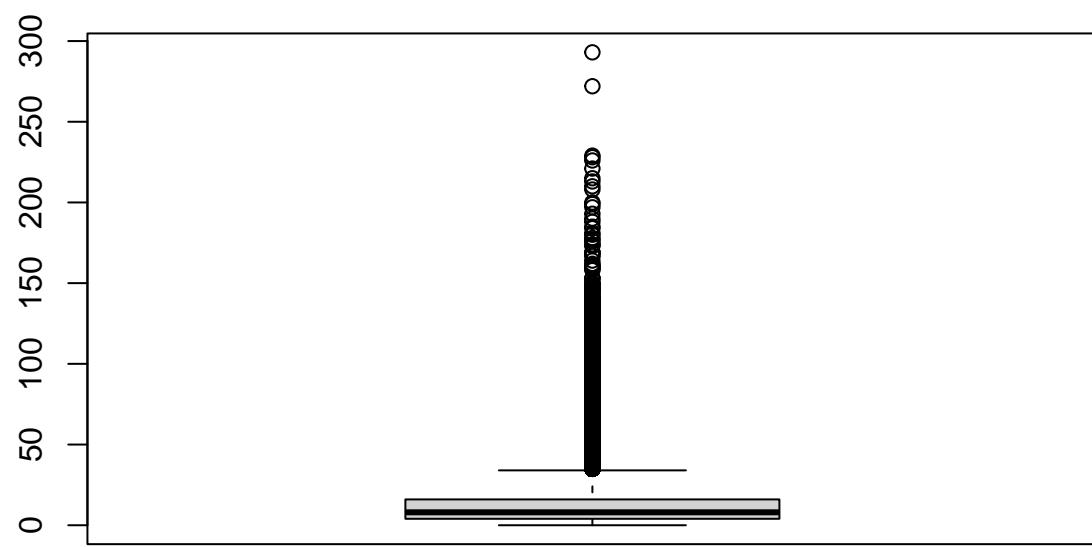


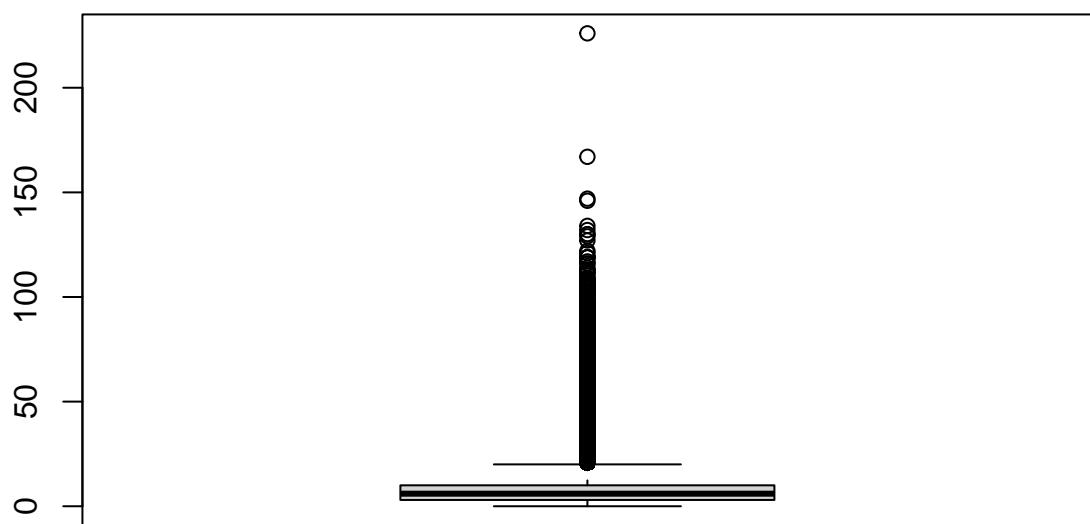


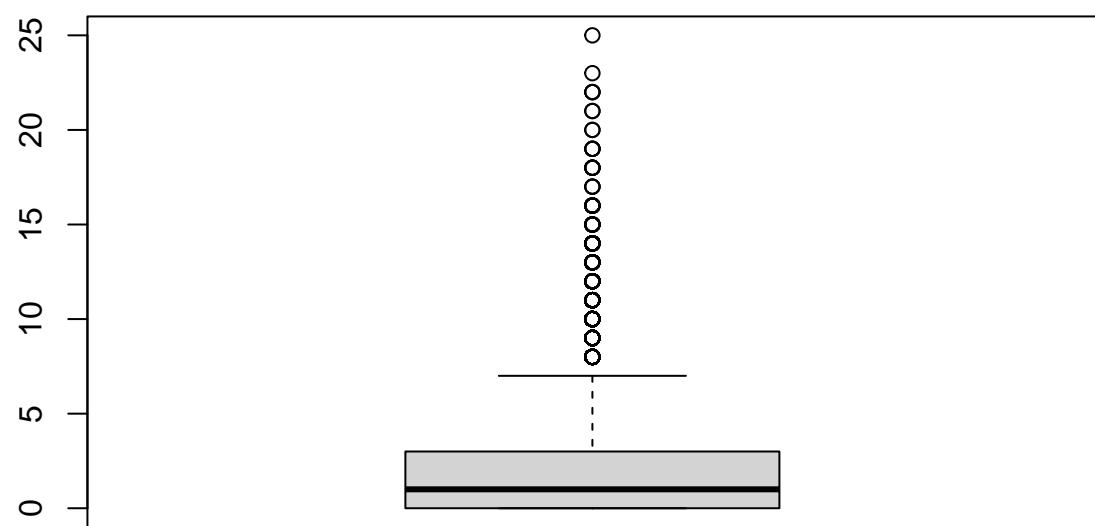


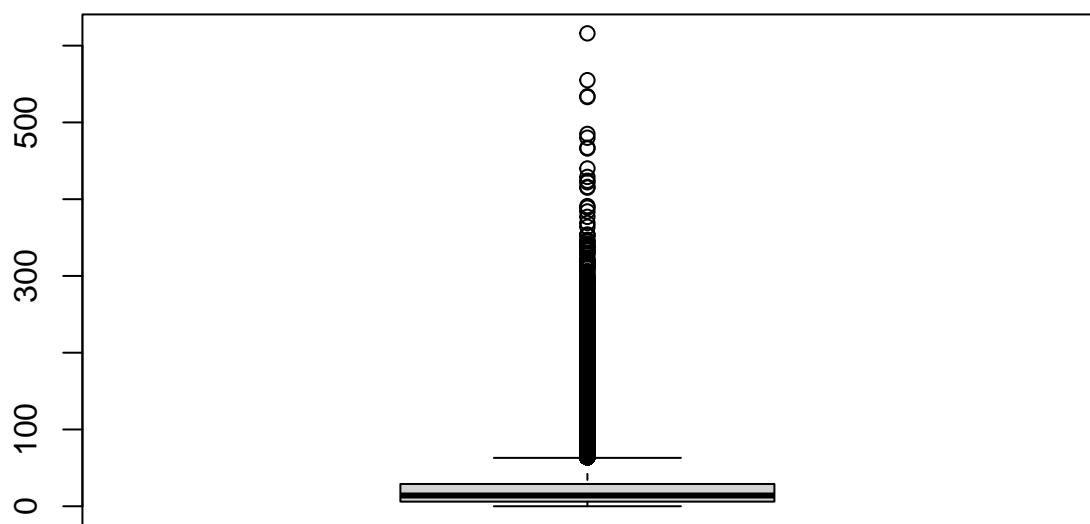


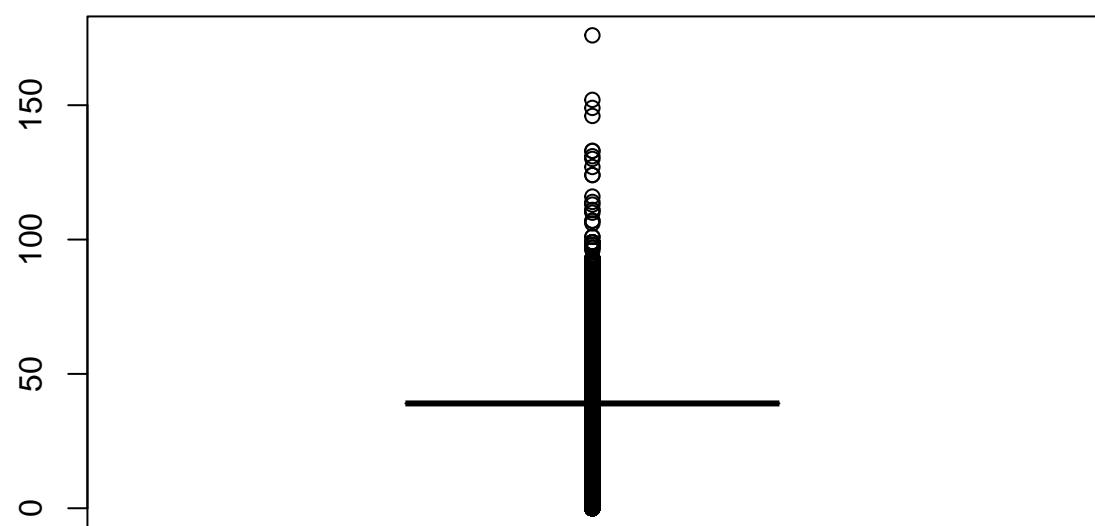


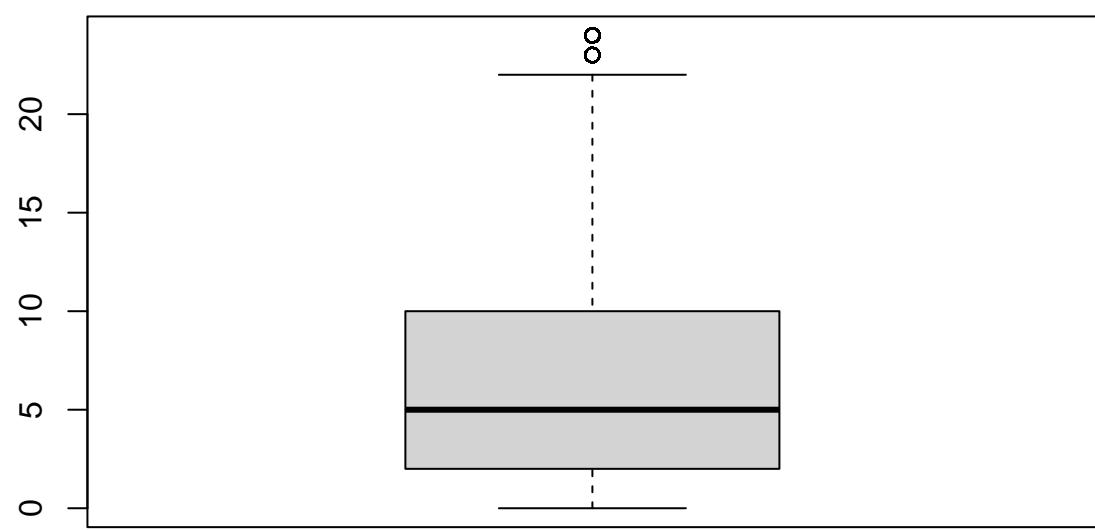


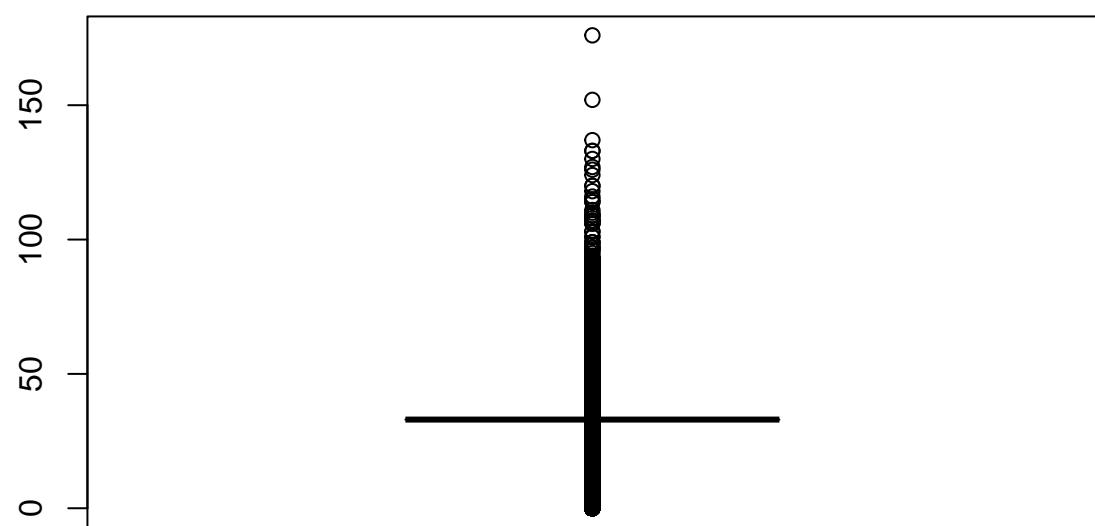


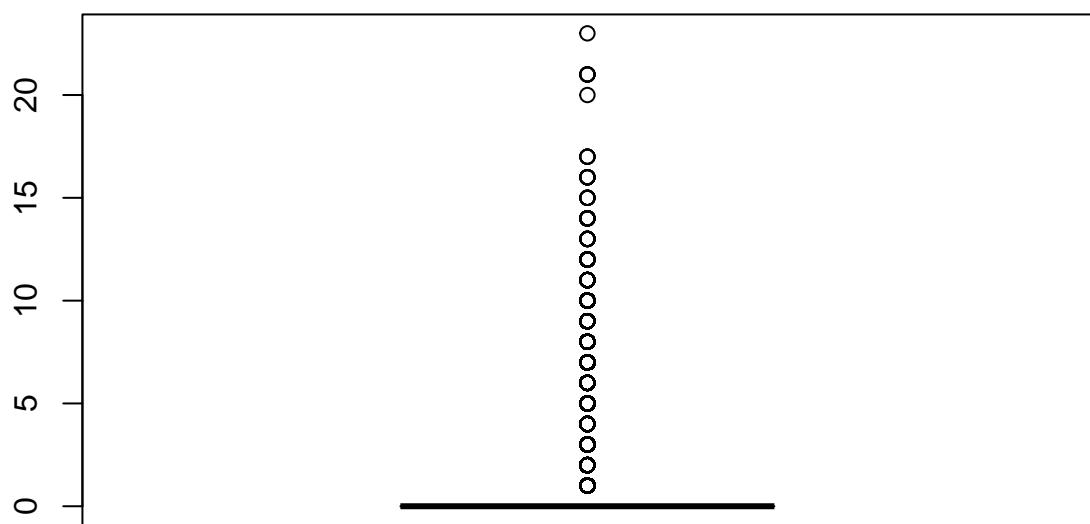


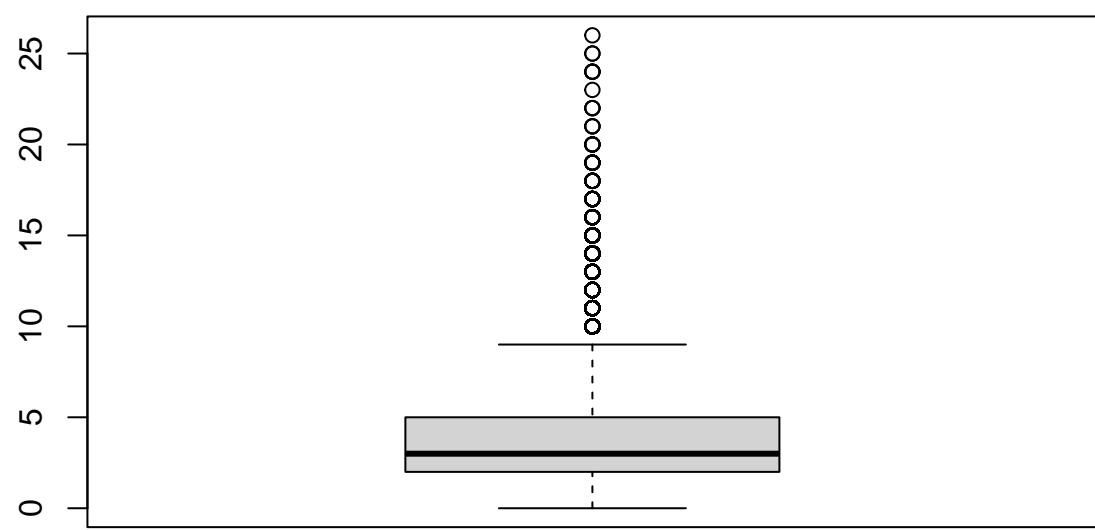


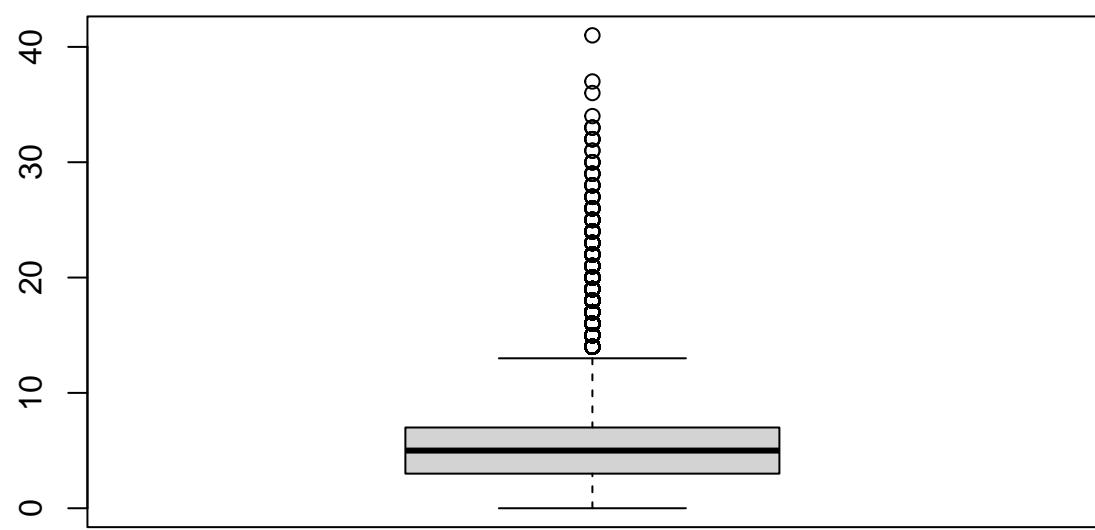


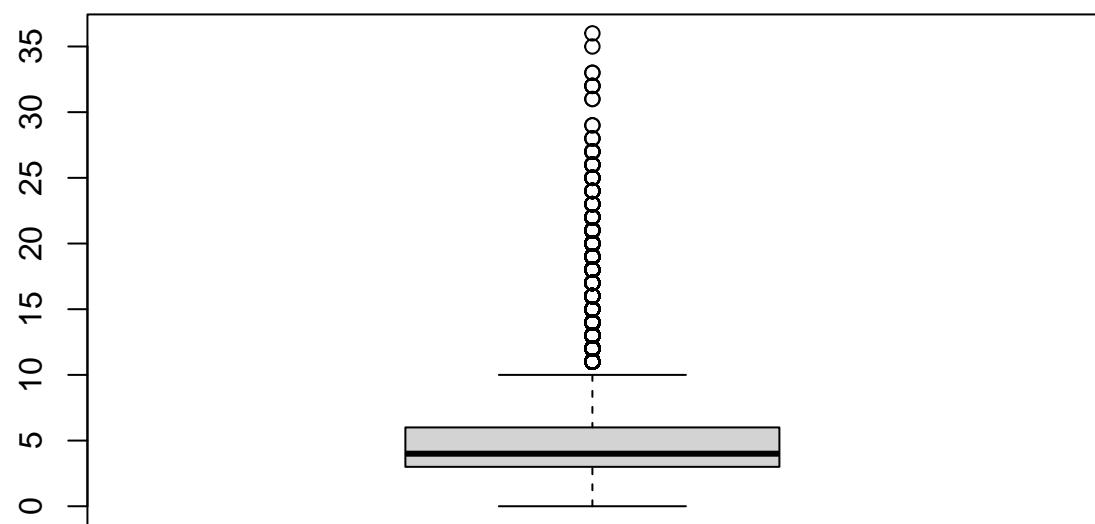


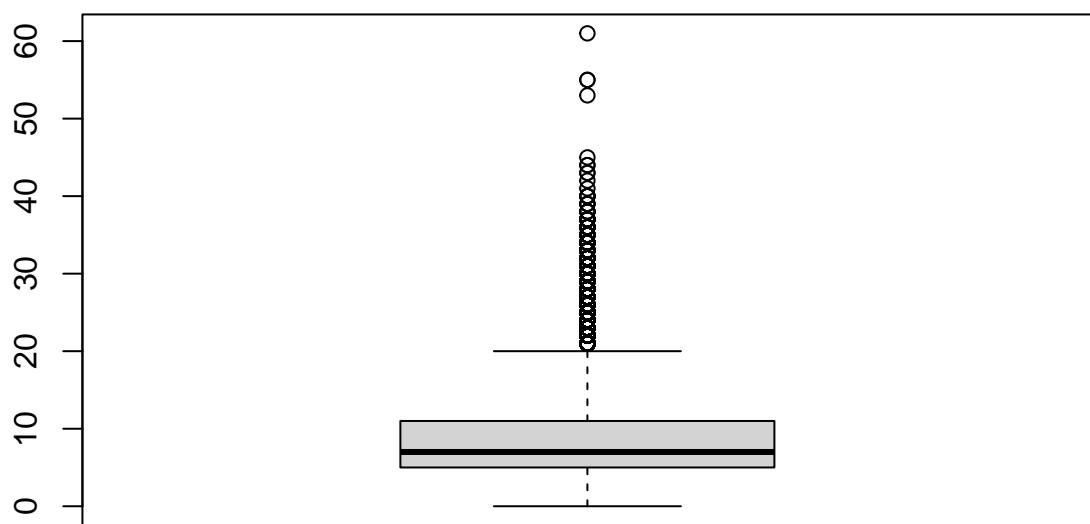


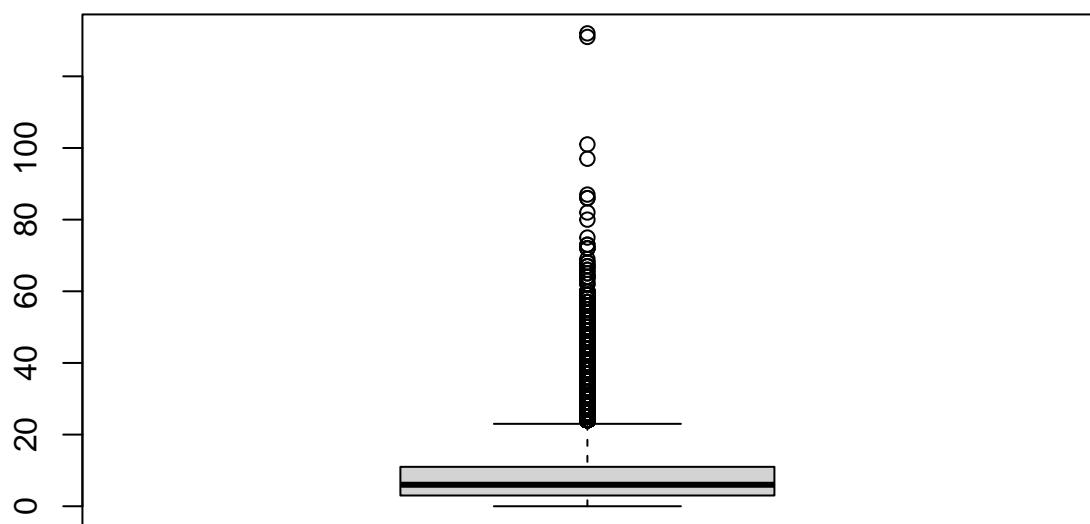


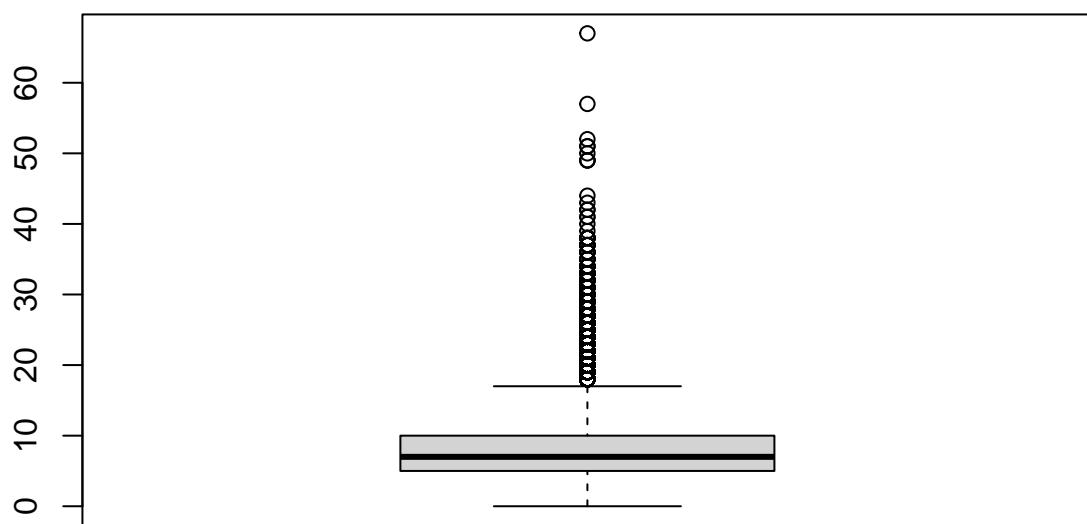


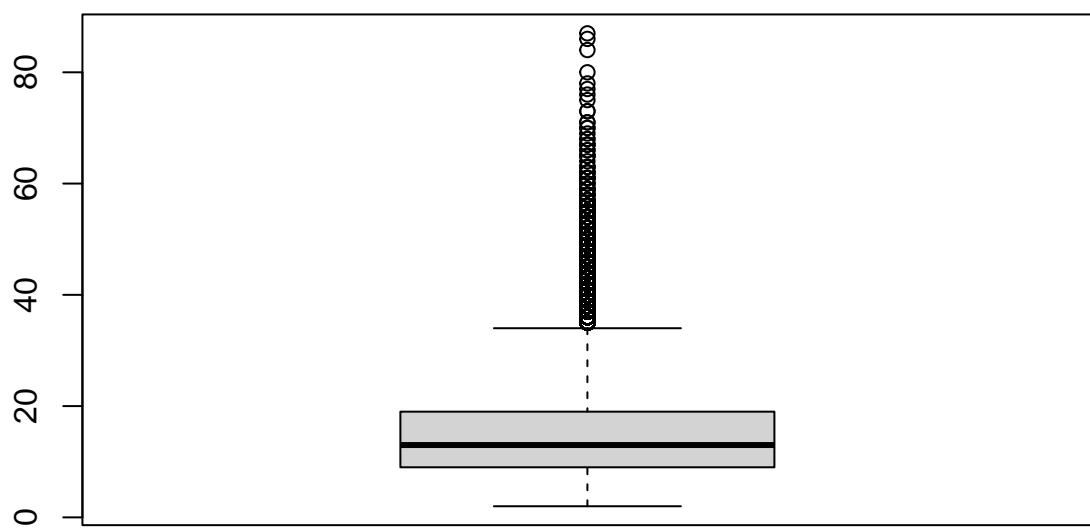


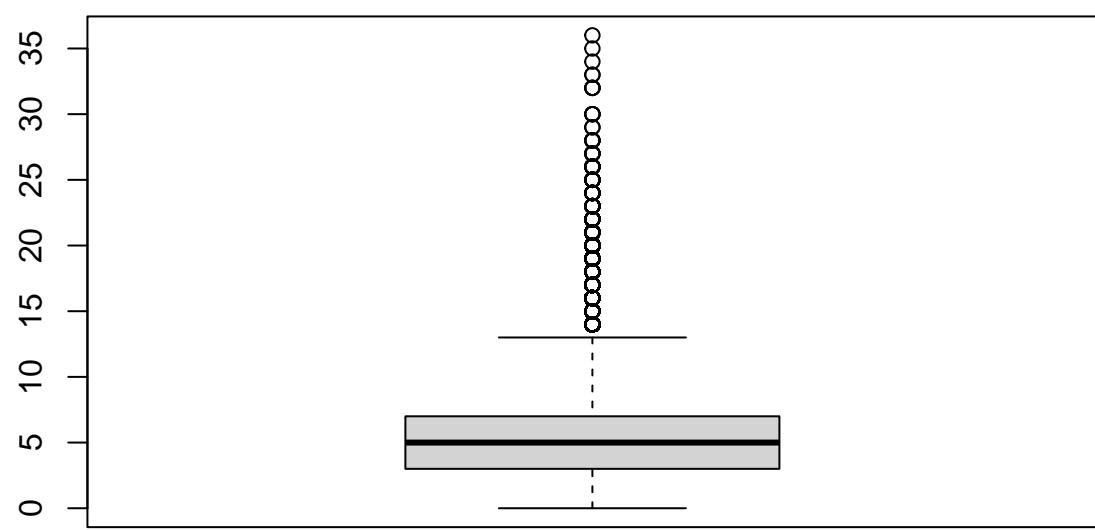


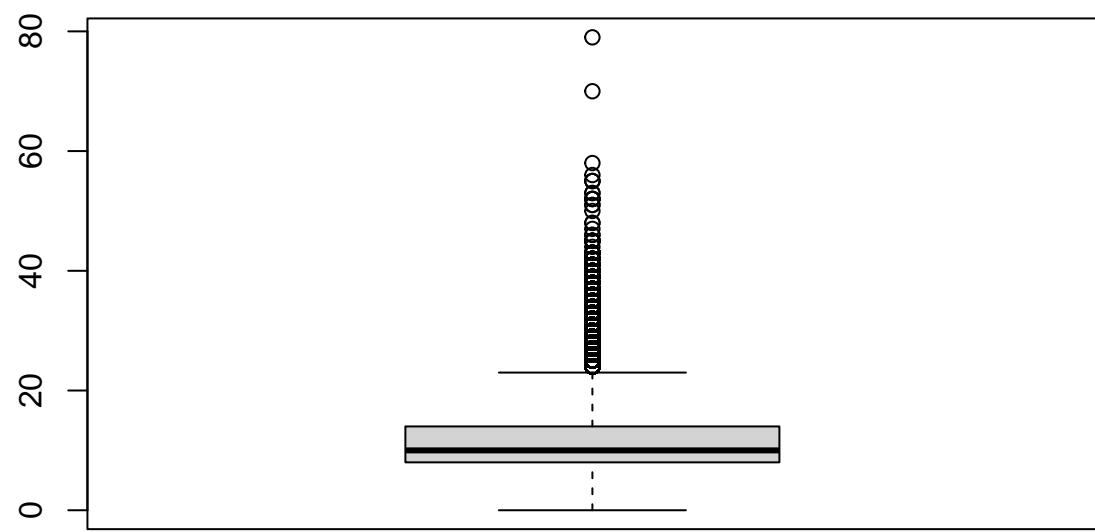


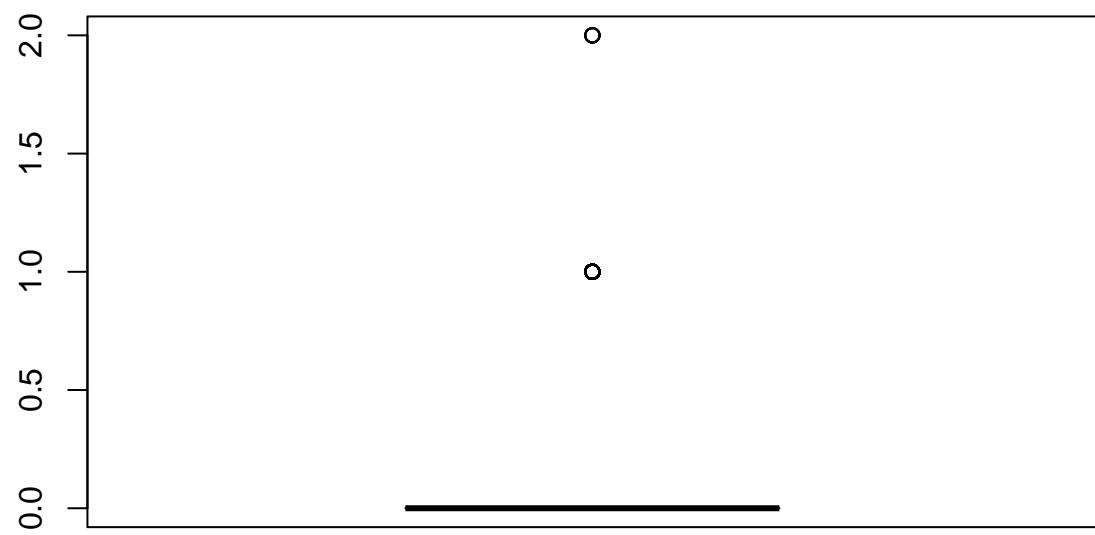


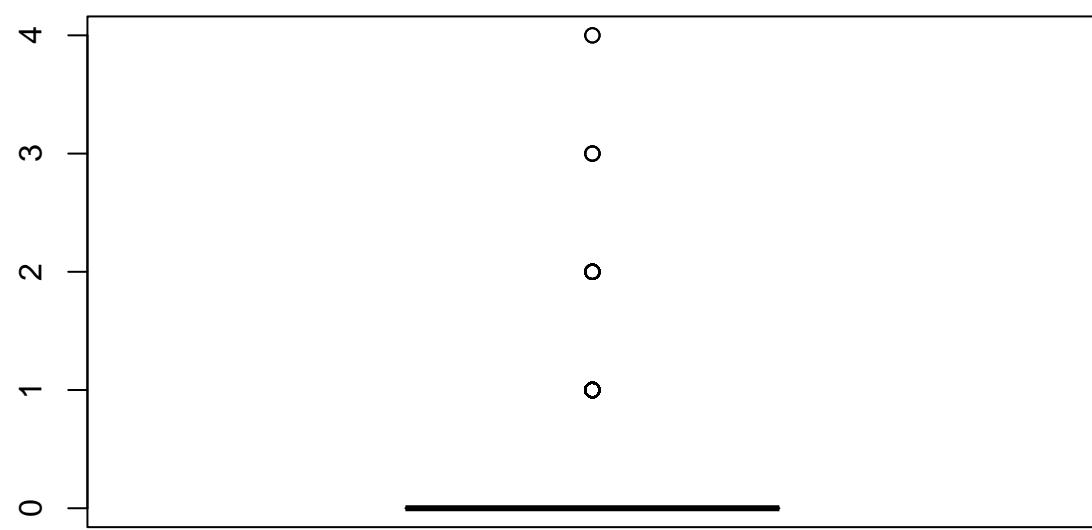


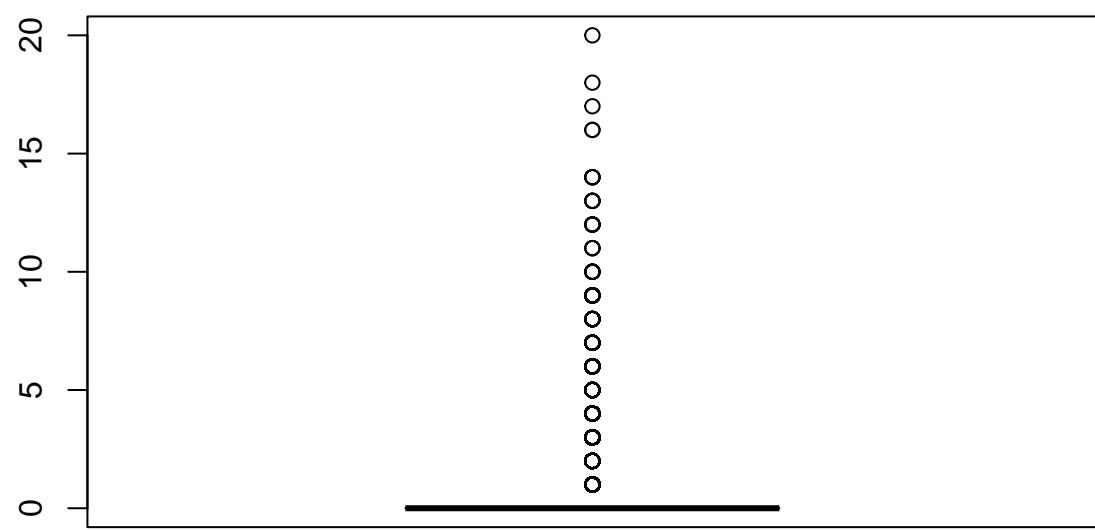


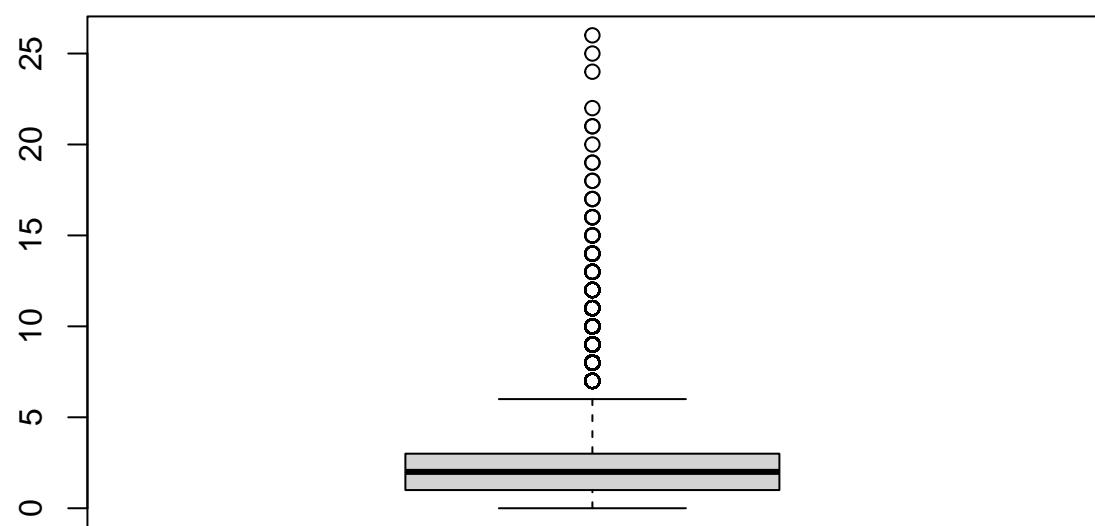


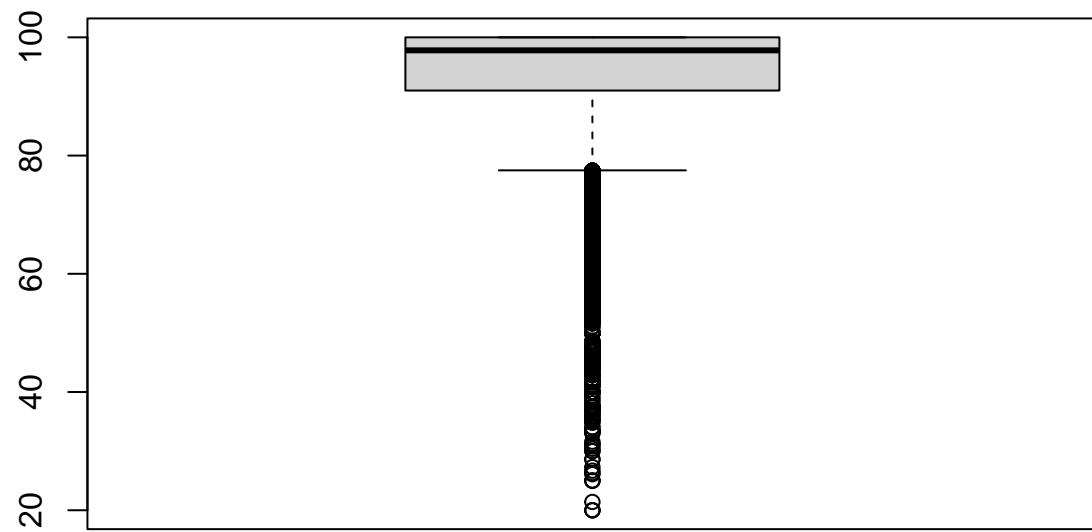


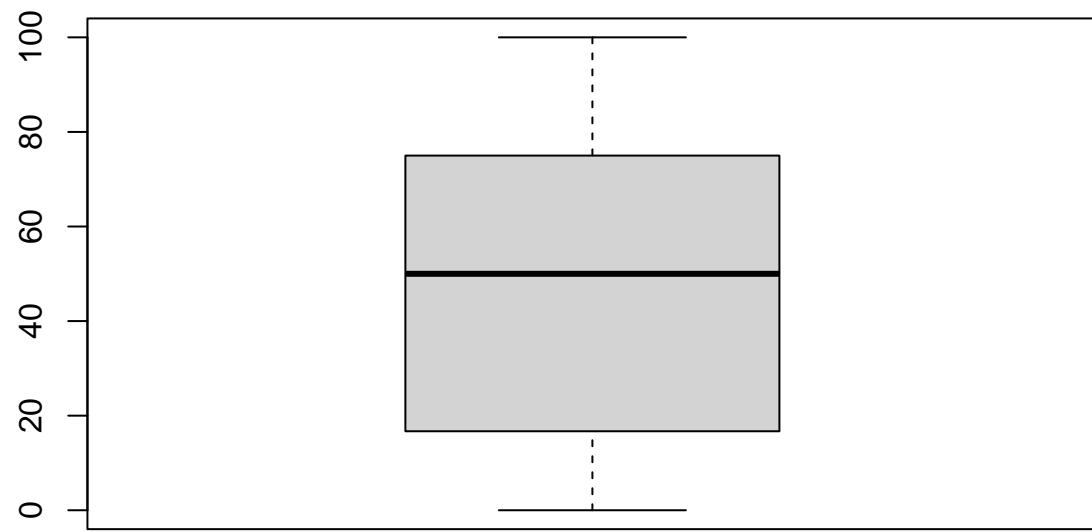


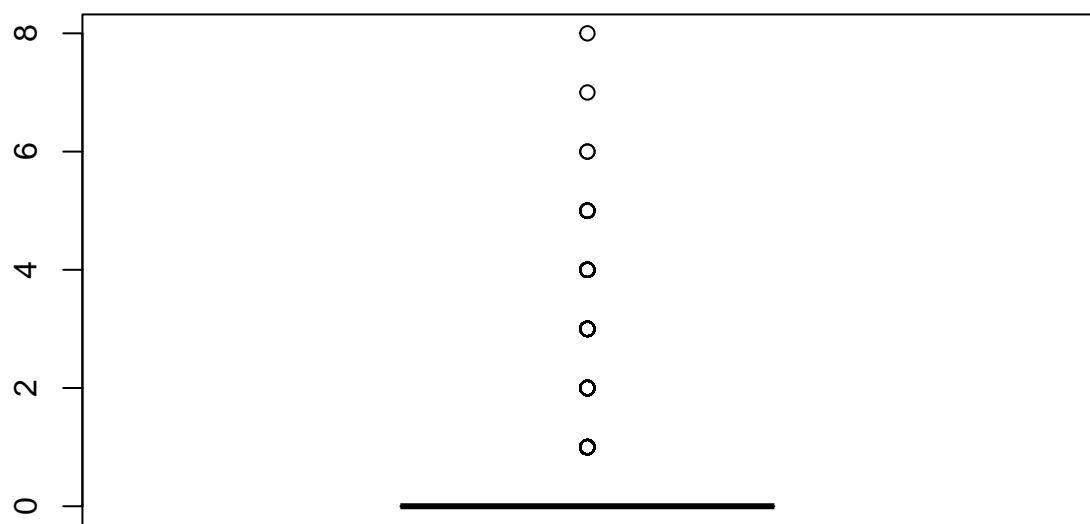


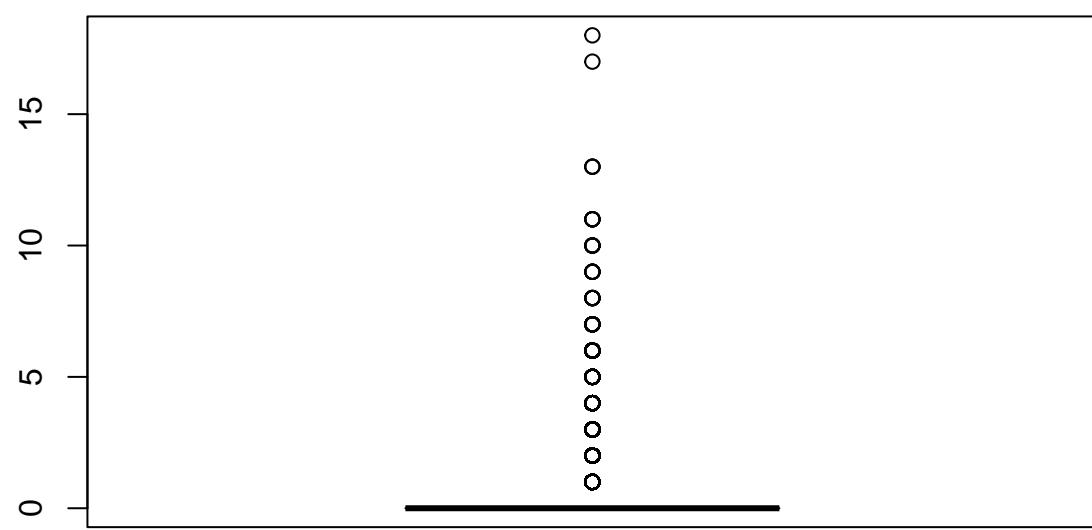


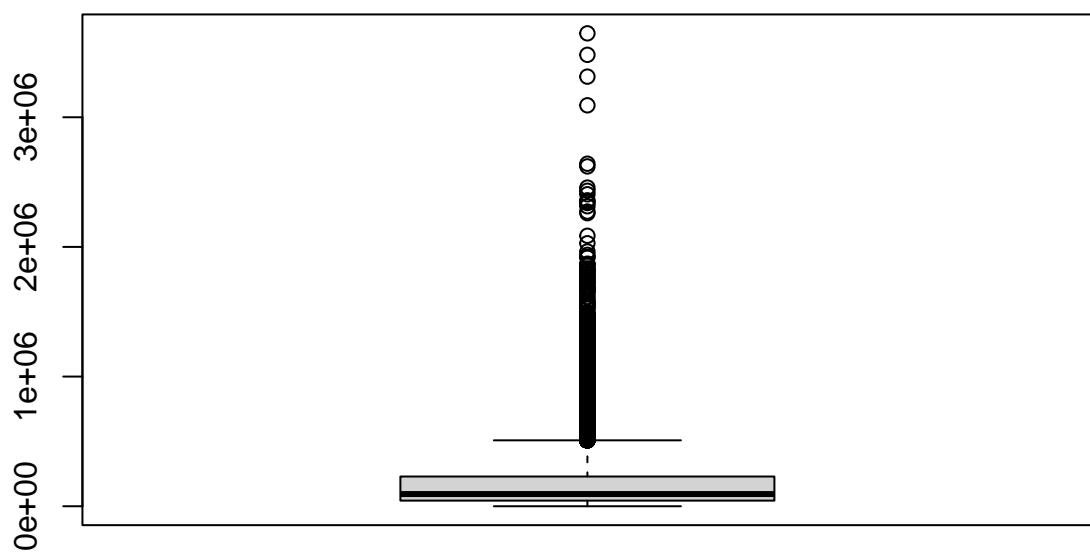


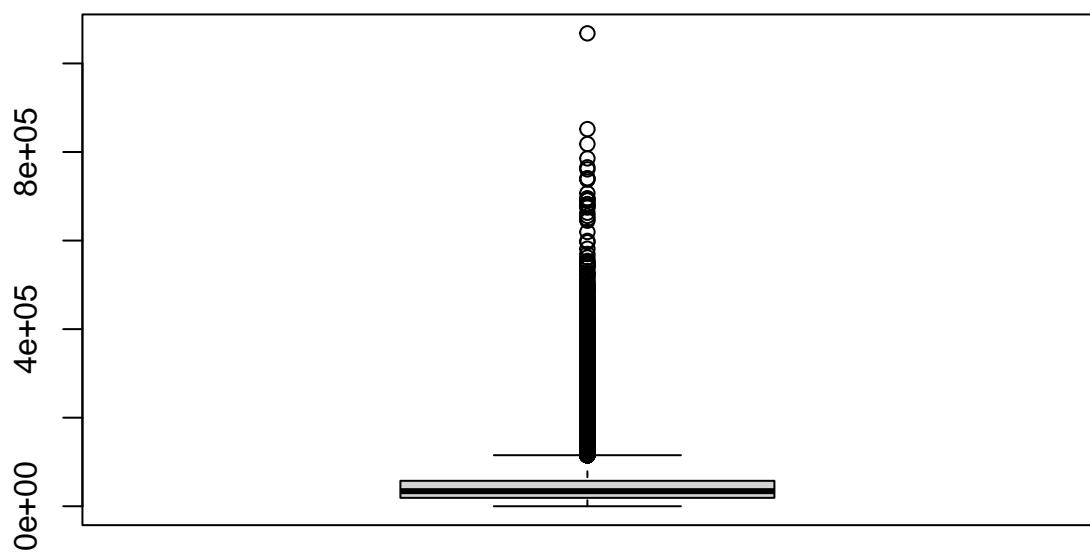


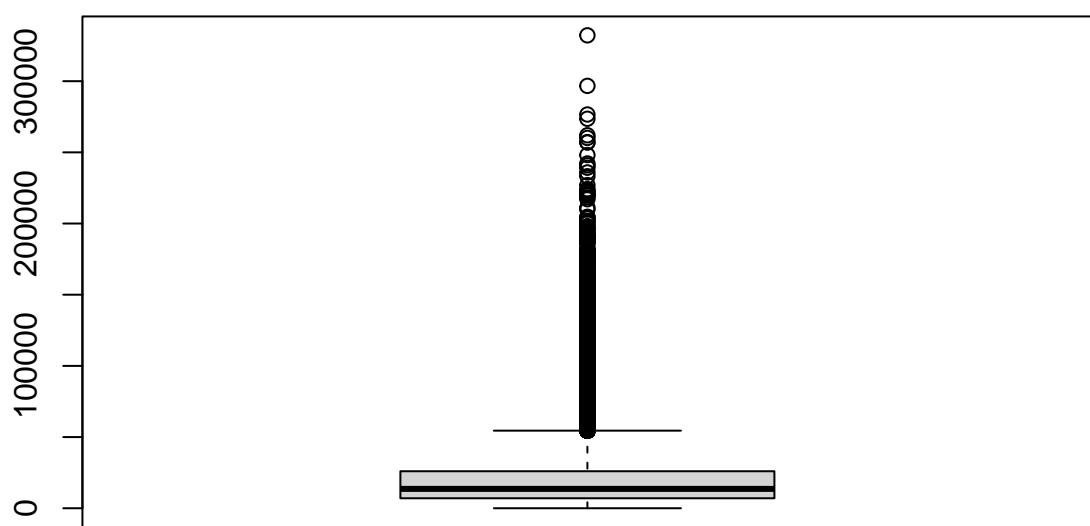


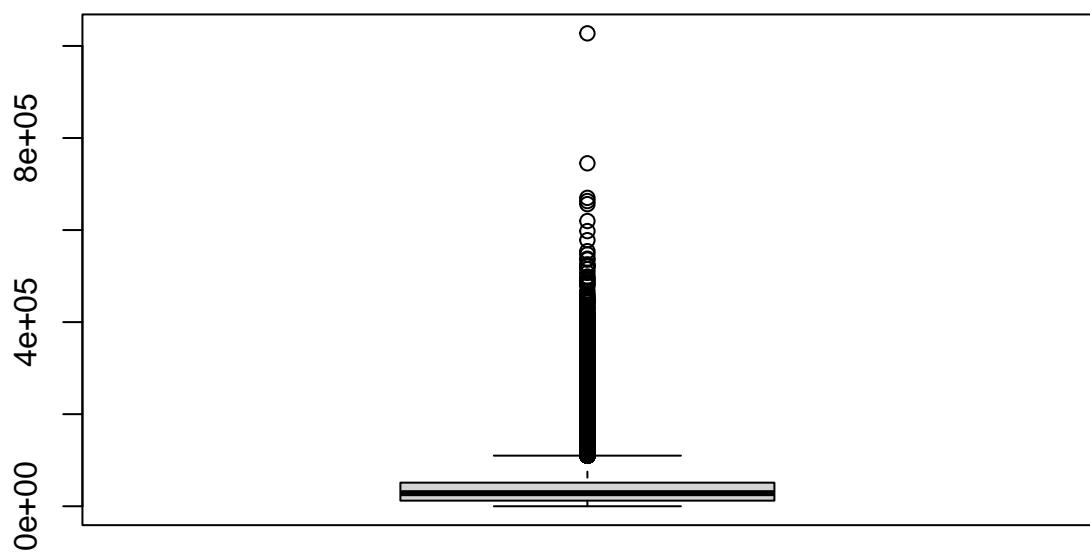


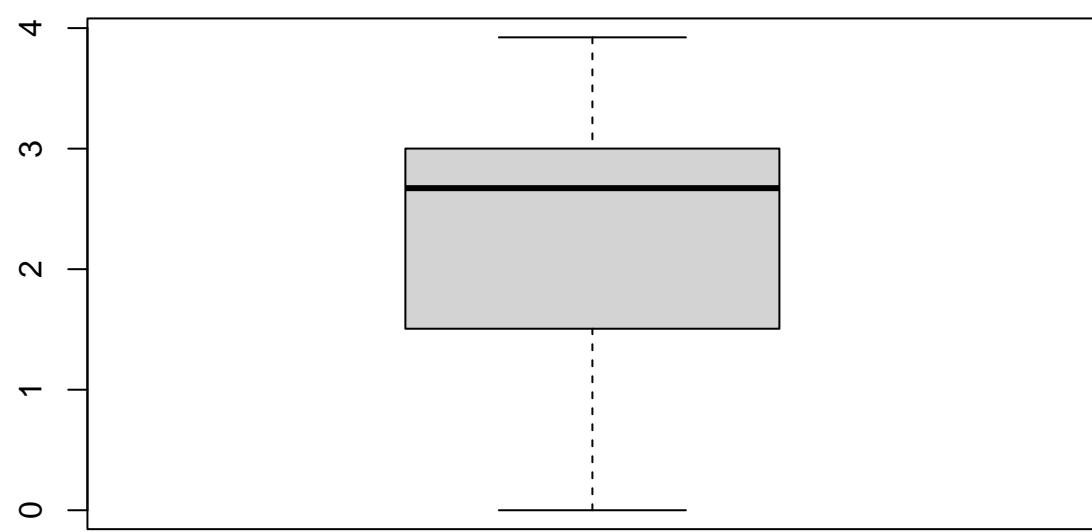


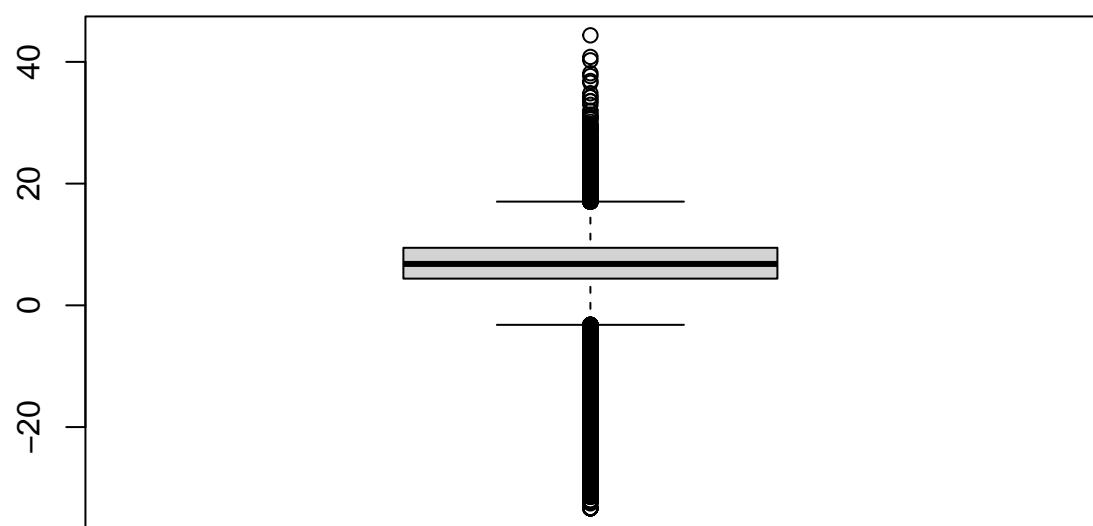


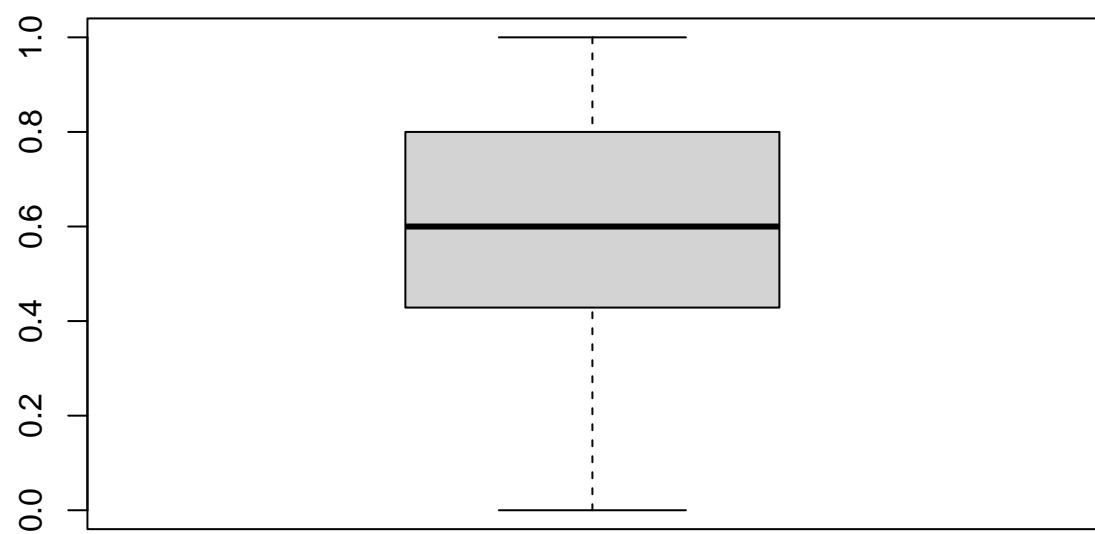


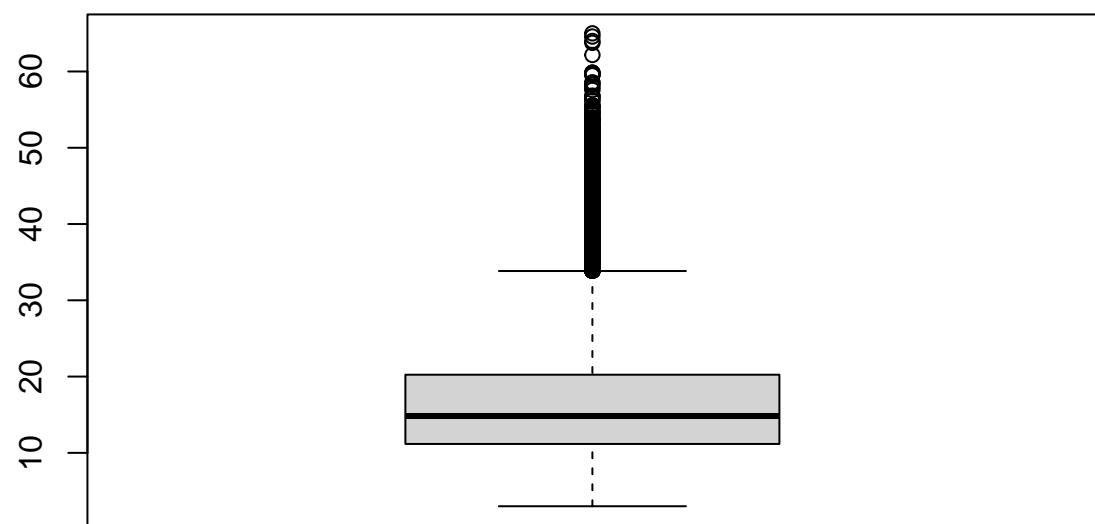


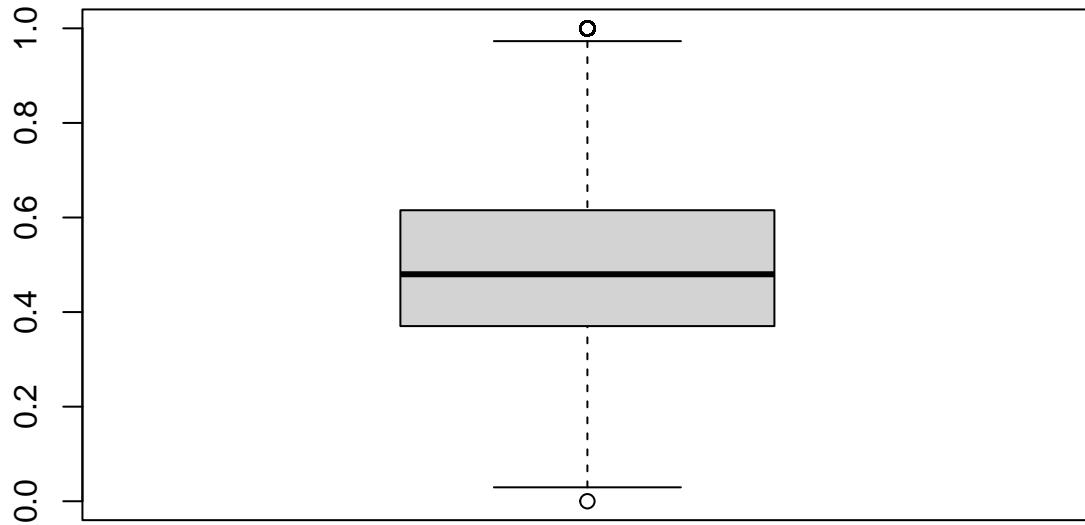












```

#-----

# Removing the outlier for the dataset
#-----out_ru <- boxplot( df_final$revol_util, plot=FALSE)$out
#out_ru #the outlier values of this variable
#to get the example-numbers (i.e. row numbers) of these
#-----out_ru_i <- which(df_final$revol_util %in% out_ru)
#to remove these examples
#-----df_final1 <- df_final [-out_ru_i, ]

# Removing the outlier for the dataset
#-----out_ru <- boxplot( df_final$annual_inc, plot=FALSE)$out
#out_ru #the outlier values of this variable
#to get the example-numbers (i.e. row numbers) of these
#-----out_ru_i <- which(df_final$annual_inc %in% out_ru)
#to remove these examples
#-----df_final1 <- df_final [-out_ru_i, ]

# Removing the outlier for the dataset
#-----out_ru <- boxplot( df_final$tot_cur_bal, plot=FALSE)$out
#out_ru #the outlier values of this variable
#to get the example-numbers (i.e. row numbers) of these
#-----out_ru_i <- which(df_final$tot_cur_bal %in% out_ru)
#to remove these examples
#-----df_final1 <- df_final [-out_ru_i, ]
#-----

```

```
##We will next develop predictive models for loan_status. #4. (a) Split the data into training and validation sets. What proportions do you consider, why?
```

```
# Splitting the dataset into train and test using random sample  
#Empirical studies show that the best results are obtained if we use 20-30% of the data for testing, an  
# we are considering 70-30 propotions  
df_final$loan_status <- as.factor(df_final$loan_status)  
library(caret)
```



```
## Loading required package: lattice
```



```
##  
## Attaching package: 'caret'
```



```
## The following object is masked from 'package:purrr':  
##  
##      lift
```



```
set.seed(3456)  
sample <- createDataPartition(df_final$loan_status, p = .7, list = FALSE, times = 1)
```



```
df_train <- df_final[sample,]  
df_test <- df_final[-sample,]
```

```
#(b) How will you evaluate performance – which measure do you consider, and why? #For evaluation of models, you should include confusion matrix related measures, as well as ROC analyses and lifts. Explain which performance measures you focus on, and why.
```

```
library(pROC)
```



```
## Type 'citation("pROC")' for a citation.
```



```
##  
## Attaching package: 'pROC'
```



```
## The following objects are masked from 'package:stats':  
##  
##      cov, smooth, var
```



```
#We will use the function auc(response, prediction) which returns the AUC value for the specified prediction
```



```
# For example:  
auc(response=df_final$loan_status, df_final$loan_amnt)
```



```
## Setting levels: control = Charged Off, case = Fully Paid
```



```
## Setting direction: controls < cases
```



```
## Area under the curve: 0.5211
```

```

# returns the auc value for loan_amt as the single predictor for loan_status

# Auc for both numeric and factor variables:
auc_output<- supply(df_final %>% mutate_if(is.factor, as.numeric) %>% select_if(is.numeric), auc, respon

## Setting levels: control = Charged Off, case = Fully Paid
## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls > cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls > cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls > cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls > cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

```

```
## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls > cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls > cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls > cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls > cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls > cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases
```

```
## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls > cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls > cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases
```

```
## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases
```

```
## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls > cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls > cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases

## Setting levels: control = Charged Off, case = Fully Paid

## Setting direction: controls < cases
```

```
## Setting levels: control = Charged Off, case = Fully Paid  
## Setting direction: controls < cases  
  
## Setting levels: control = Charged Off, case = Fully Paid  
## Setting direction: controls < cases  
  
## Setting levels: control = Charged Off, case = Fully Paid  
## Setting direction: controls < cases  
  
## Setting levels: control = Charged Off, case = Fully Paid  
## Setting direction: controls < cases  
  
## Setting levels: control = Charged Off, case = Fully Paid  
## Setting direction: controls < cases  
  
## Setting levels: control = Charged Off, case = Fully Paid  
## Setting direction: controls < cases  
  
## Setting levels: control = Charged Off, case = Fully Paid  
## Setting direction: controls < cases  
  
## Setting levels: control = Charged Off, case = Fully Paid  
## Setting direction: controls < cases  
  
## Setting levels: control = Charged Off, case = Fully Paid  
## Setting direction: controls > cases  
  
## Setting levels: control = Charged Off, case = Fully Paid  
## Setting direction: controls < cases  
  
## Setting levels: control = Charged Off, case = Fully Paid  
## Setting direction: controls > cases  
  
## Setting levels: control = Charged Off, case = Fully Paid  
## Setting direction: controls < cases  
  
## Setting levels: control = Charged Off, case = Fully Paid  
## Setting direction: controls > cases
```

```

# we can use the tidy(..) function from the broom package - which converts the 'messy' output into a tibble
library(broom)

# To find the variables which has AUC greater than 0.5
tidy(auc_output[auc_output > 0.5]) %>% view()

## Warning: 'tidy.numeric' is deprecated.
## See help("Deprecated")

# These are the performance metrics we will be focusing on
#Accuracy
#Confusion Matrix
#Precision and Recall
#F1-score
#AU-ROC
#Lifts

```

5. Develop a decision tree model to predict default.

#Train decision tree models (use either rpart or c50) #What parameters do you experiment with, and what performance do you obtain (on training and validation sets)? Clearly tabulate your results and briefly describe your findings.

```
glimpse(df_train)
```

```

## Rows: 70,001
## Columns: 74
## $ loan_amnt <dbl> 28000, 7200, 1600, 25000, 4800, 8000, 2~  

## $ int_rate <dbl> 5.32, 14.99, 13.33, 15.31, 12.69, 14.33~  

## $ installment <dbl> 843.22, 249.56, 54.17, 870.44, 161.02, ~  

## $ grade <fct> A, C, C, C, C, A, B, C, A, C, D, C, ~  

## $ sub_grade <fct> A1, C5, C3, C2, C2, C1, A4, B4, C4, A2,~  

## $ home_ownership <fct> MORTGAGE, RENT, RENT, MORTGAGE, MORTGAG~  

## $ annual_inc <dbl> 140000, 20000, 50000, 98000, 100000, 90~  

## $ verification_status <fct> Source Verified, Source Verified, Verif~  

## $ loan_status <fct> Fully Paid, Fully Paid, Fully Paid, Ful~  

## $ pymnt_plan <fct> n, n, n, n, n, n, n, n, n, ~  

## $ purpose <fct> credit_card, debt_consolidation, debt_c~  

## $ addr_state <fct> MO, CT, IL, OH, NJ, CA, NJ, CA, GA, TX,~  

## $ dti <dbl> 12.83, 23.44, 11.31, 24.16, 9.94, 11.52~  

## $ delinq_2yrs <dbl> 0, 0, 0, 6, 0, 0, 0, 1, 0, 3, 0, 1, ~  

## $ earliest_cr_line <dttm> 1994-12-01, 1988-08-01, 2007-09-01, 19~  

## $ inq_last_6mths <dbl> 0, 0, 0, 0, 1, 1, 1, 0, 2, 1, 1, 1, ~  

## $ mths_since_last_delinq <dbl> 31, 31, 31, 13, 31, 57, 51, 31, 19, 31,~  

## $ mths_since_last_record <dbl> 69, 69, 69, 69, 65, 69, 69, 69, 69, 69,~  

## $ open_acc <dbl> 16, 7, 7, 14, 6, 12, 16, 20, 2, 20, 11,~  

## $ pub_rec <dbl> 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, ~  

## $ revol_bal <dbl> 74178, 11907, 7434, 32012, 20268, 6178,~  

## $ revol_util <dbl> 41.5, 55.6, 67.0, 73.1, 82.4, 37.0, 46.~  

## $ total_acc <dbl> 31, 18, 9, 35, 13, 35, 41, 48, 20, 34, ~

```

```

## $ initial_list_status
## $ total_pymnt
## $ last_pymnt_d
## $ collections_12_mths_ex_med
## $ mths_since_last_major_derog
## $ acc_now_delinq
## $ tot_coll_amt
## $ tot_cur_bal
## $ total_rev_hi_lim
## $ acc_open_past_24mths
## $ avg_cur_bal
## $ bc_open_to_buy
## $ bc_util
## $ chargeoff_within_12_mths
## $ delinq_amnt
## $ mo_sin_old_il_acct
## $ mo_sin_old_rev_tl_op
## $ mo_sin_rcnt_rev_tl_op
## $ mo_sin_rcnt_tl
## $ mort_acc
## $ mths_since_recent_bc
## $ mths_since_recent_bc_dlq
## $ mths_since_recent_inq
## $ mths_since_recent_revol_delinq
## $ num_accts_ever_120_pd
## $ num_actv_bc_tl
## $ num_actv_rev_tl
## $ num_bc_sats
## $ num_bc_tl
## $ num_il_tl
## $ num_op_rev_tl
## $ num_rev_accts
## $ num_rev_tl_bal_gt_0
## $ num_sats
## $ num_t1_120dpd_2m
## $ num_t1_30dpd
## $ num_t1_90g_dpd_24m
## $ num_t1_op_past_12m
## $ pct_t1_nvr_dlq
## $ percent_bc_gt_75
## $ pub_rec_bankruptcies
## $ tax_liens
## $ tot_hi_cred_lim
## $ total_bal_ex_mort
## $ total_bc_limit
## $ total_il_high_credit_limit
## $ actual_term
## $ actual_return
## $ propSatisBankcardAccts
## $ borrHistory
## $ openAccRatio

varsOmit <- c('actual_term', 'actual_return', 'propSatisBankcardAccts', 'openAccRatio', 'last_pymnt_d')

<fct> w, f, w, f, f, f, f, w, f, f, ~
<dbl> 29436.890, 8971.949, 1948.720, 31335.53~
<dttm> 2016-07-01, 2017-11-01, 2018-11-01, 20~
<dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, ~
<dbl> 43, 43, 43, 13, 43, 57, 43, 43, 19, 43, ~
<dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, ~
<dbl> 0, 0, 0, 57, 0, 6907, 0, 0, 0, 308, 0, ~
<dbl> 364466, 11907, 16610, 252407, 299546, 2~
<dbl> 136800, 21400, 11100, 43800, 24600, 167~
<dbl> 3, 1, 5, 4, 7, 6, 4, 5, 0, 7, 5, 4, 5, ~
<dbl> 26033, 1701, 2373, 18029, 49924, 2295, ~
<dbl> 54787, 2329, 0, 1516, 74, 8826, 5098, 3~
<dbl> 43.2, 82.9, 100.7, 93.6, 99.6, 28.2, 64~
<dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, ~
<dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, ~
<dbl> 194, 128, 31, 195, 154, 195, 238, 150, ~
<dbl> 245, 315, 97, 229, 150, 195, 206, 260, ~
<dbl> 16, 39, 1, 8, 11, 9, 3, 1, 26, 1, 4, 3, ~
<dbl> 16, 20, 1, 8, 11, 9, 3, 1, 26, 1, 2, 3, ~
<dbl> 7, 3, 0, 1, 1, 0, 1, 3, 5, 2, 1, 1, ~
<dbl> 16, 47, 45, 34, 11, 9, 3, 7, 34, 2, 5, ~
<dbl> 39, 31, 39, 39, 39, 39, 51, 39, 39, 39, ~
<dbl> 15, 5, 16, 8, 19, 4, 3, 4, 23, 1, 6, 4, ~
<dbl> 33, 31, 33, 33, 33, 33, 51, 33, 33, 33, ~
<dbl> 0, 0, 0, 6, 0, 3, 0, 0, 1, 0, 2, 0, 0, ~
<dbl> 5, 4, 2, 4, 3, 3, 3, 1, 6, 5, 1, 3, ~
<dbl> 7, 6, 3, 8, 4, 5, 7, 7, 1, 7, 7, 1, 7, ~
<dbl> 10, 4, 2, 4, 3, 3, 3, 5, 2, 10, 5, 1, 8~
<dbl> 11, 6, 3, 8, 6, 8, 12, 17, 11, 13, 8, 1~
<dbl> 7, 0, 3, 15, 4, 22, 20, 12, 3, 8, 9, 4, ~
<dbl> 14, 7, 5, 11, 4, 5, 9, 16, 2, 17, 7, 4, ~
<dbl> 17, 15, 6, 19, 8, 11, 21, 34, 14, 21, 1~
<dbl> 7, 6, 3, 8, 4, 5, 7, 7, 1, 7, 7, 1, 8, ~
<dbl> 16, 7, 7, 14, 6, 12, 16, 20, 2, 20, 11, ~
<dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, ~
<dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, ~
<dbl> 0, 0, 0, 6, 0, 0, 0, 1, 0, 2, 0, 0, ~
<dbl> 0, 0, 2, 2, 1, 4, 2, 4, 0, 5, 3, 4, 4, ~
<dbl> 100.0, 94.4, 100.0, 82.0, 100.0, 91.0, ~
<dbl> 22.2, 75.0, 100.0, 100.0, 100.0, 33.3, ~
<dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, ~
<dbl> 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, ~
<dbl> 457375, 21400, 28900, 309453, 313935, 5~
<dbl> 94529, 11907, 16610, 56406, 25455, 2754~
<dbl> 94900, 13600, 5600, 23700, 19100, 12300~
<dbl> 33575, 0, 17800, 60332, 7335, 34723, 15~
<dbl> 1.1690623, 3.0006845, 3.0855578, 3.0006~
<dbl> 4.389629, 8.201598, 7.063549, 8.445451, ~
<dbl> 0.9090909, 0.6666667, 0.6666667, 0.5000~
<dbl> 20.413415, 26.250513, 8.082136, 18.8336~
<dbl> 0.5161290, 0.3888889, 0.7777778, 0.4000~

varsOmit <- c('actual_term', 'actual_return', 'propSatisBankcardAccts', 'openAccRatio', 'last_pymnt_d')

```

```

library(rpart)

DT <- rpart(loan_status ~ ., data=df_train %>% select(-all_of(vars0mit)), method="class", parms = list(split = "information"))
printcp(DT)  #reasonable ? (If the tree does not grow at all, maybe set a lower value of cp?)

## 
## Classification tree:
## rpart(formula = loan_status ~ ., data = df_train %>% select(-all_of(vars0mit)),
##       method = "class", parms = list(split = "information"), control = rpart.control(minsplit = 30))
##
## Variables actually used in tree construction:
## [1] installment loan_amnt    total_pymnt
##
## Root node error: 9650/70001 = 0.13786
##
## n= 70001
##
##          CP nsplit rel error  xerror     xstd
## 1 0.140570      0  1.00000  1.00000 0.0094521
## 2 0.090829      2  0.71886  0.71865 0.0081911
## 3 0.034922      4  0.53720  0.53876 0.0071891
## 4 0.031917      6  0.46736  0.51316 0.0070296
## 5 0.017098      8  0.40352  0.43720 0.0065250
## 6 0.016995     10  0.36933  0.39710 0.0062368
## 7 0.015492     12  0.33534  0.36819 0.0060181
## 8 0.010984     14  0.30435  0.33016 0.0057145
## 9 0.010000     18  0.26041  0.30311 0.0054861

#variable importance
DT$variable.importance

##           installment        loan_amnt       total_pymnt   annual_inc
## 1.192811e+04 1.084065e+04 9.250698e+03 2.548170e+02
##         revol_bal    total_rev_hi_lim      sub_grade    addr_state
## 2.347194e+02 1.722418e+02 9.363193e+01 8.561151e+01
##         int_rate            grade      purpose mo_sin_old_il_acct
## 7.592987e+01 2.430129e+01 1.469923e+01 3.575404e+00
##          dti            total_acc    tot_hi_cred_lim      open_acc
## 2.986538e+00 2.284532e+00 1.833686e+00 4.078342e-01
##         avg_cur_bal
## 2.457434e-01

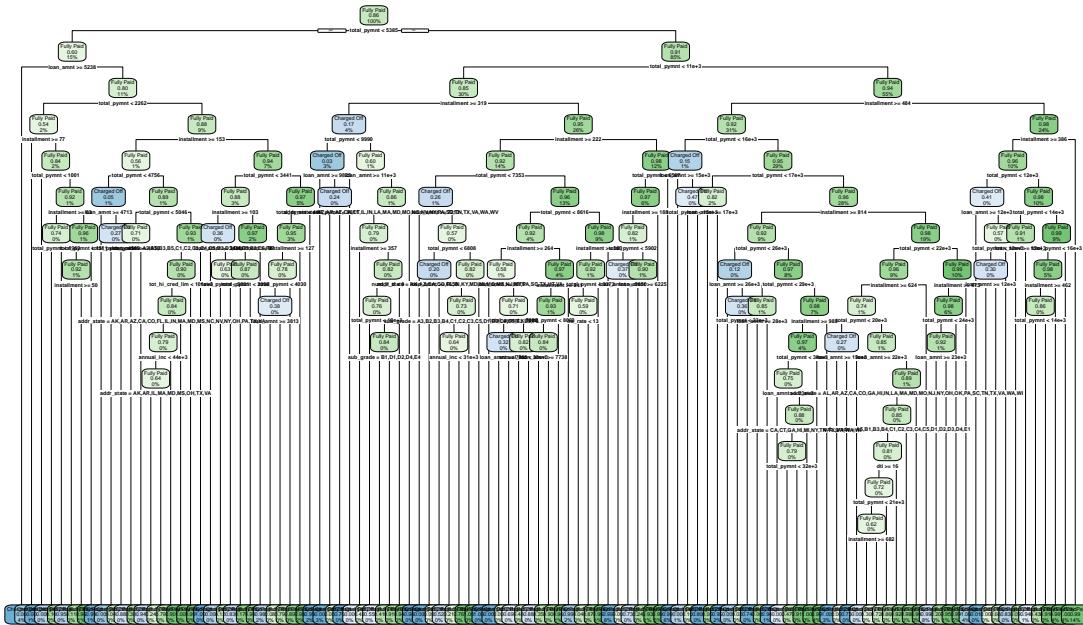
# Changing hyper parameters
DT <- rpart(loan_status ~ ., data=df_train %>% select(-all_of(vars0mit)), method="class", parms = list(split = "information"))

library(rpart.plot)
rpart.plot(DT, main="Decision Tree")

## Warning: labs do not fit even at cex 0.15, there may be some overplotting

```

Decision Tree



```
#prune the tree -- check for performance with different cp levels
printcp(DT)
```

```
##
## Classification tree:
## rpart(formula = loan_status ~ ., data = df_train %>% select(-all_of(vars0mit)),
##       method = "class", parms = list(split = "information"), control = rpart.control(cp = 1e-04,
##       minsplit = 50))
##
## Variables actually used in tree construction:
## [1] addr_state      annual_inc       dti           installment
## [5] int_rate        loan_amnt       num_il_tl      sub_grade
## [9] tot_hi_cred_lim total_pymnt
##
## Root node error: 9650/70001 = 0.13786
##
## n= 70001
##
##          CP nsplit rel error xerror      xstd
## 1  0.14056995      0  1.00000 1.00000 0.0094521
## 2  0.09082902      2  0.71886 0.71896 0.0081927
## 3  0.03492228      4  0.53720 0.53917 0.0071916
## 4  0.03191710      6  0.46736 0.50425 0.0069729
## 5  0.01709845      8  0.40352 0.42269 0.0064226
## 6  0.01699482     10  0.36933 0.38010 0.0061094
## 7  0.01549223     12  0.33534 0.34021 0.0057967
```

```

## 8 0.01098446      14 0.30435 0.31751 0.0056092
## 9 0.00984456      18 0.26041 0.29005 0.0053717
## 10 0.00575130     19 0.25057 0.26073 0.0051036
## 11 0.00512953     21 0.23907 0.24974 0.0049989
## 12 0.00367876     23 0.22881 0.24187 0.0049222
## 13 0.00331606     26 0.21741 0.23016 0.0048056
## 14 0.00253886     27 0.21409 0.22031 0.0047050
## 15 0.00227979     31 0.20259 0.21098 0.0046074
## 16 0.00212435     35 0.19337 0.20746 0.0045699
## 17 0.00186528     37 0.18912 0.20176 0.0045085
## 18 0.00172712     39 0.18539 0.19699 0.0044564
## 19 0.00170984     44 0.17606 0.19420 0.0044255
## 20 0.00134715     46 0.17264 0.18715 0.0043467
## 21 0.00113990     51 0.16591 0.18052 0.0042710
## 22 0.00107081     52 0.16477 0.17575 0.0042156
## 23 0.00082902     55 0.16155 0.17192 0.0041705
## 24 0.00077720     61 0.15658 0.16953 0.0041422
## 25 0.00075993     63 0.15503 0.16933 0.0041397
## 26 0.00072539     71 0.14746 0.16922 0.0041385
## 27 0.00067358     73 0.14601 0.16953 0.0041422
## 28 0.00041451     75 0.14466 0.16684 0.0041099
## 29 0.00037997     78 0.14342 0.16601 0.0040999
## 30 0.00020725     81 0.14228 0.16705 0.0041124
## 31 0.00018653     84 0.14166 0.16902 0.0041360
## 32 0.00017271     89 0.14073 0.17036 0.0041521
## 33 0.00016580     92 0.14021 0.17088 0.0041582
## 34 0.00010363     97 0.13938 0.17306 0.0041840
## 35 0.00010000    106 0.13845 0.17565 0.0042144

```

```

DT1<- prune.rpart(DT, cp=0.00022)

#.....
#Training the model considering a more balanced training dataset

DTb<- rpart(loan_status ~., data=df_train %>% select(-all_of(vars0mit)), method="class", parms =list(sy

# Decision tree model evaluation

# Predicting the model on train data
df_table_train <-table(pred = predict(DT1,df_train, type='class'), true=df_train$loan_status)
df_table_train

##          true
## pred      Charged Off Fully Paid
##   Charged Off      8366       89
##   Fully Paid      1284     60262

mean(predict(DT1,df_train, type='class') ==df_train$loan_status)

## [1] 0.980386

```

```

# Findings : Accuracy is 86.5%

#Confusion Matrix for train data
confusionMatrix(df_table_train,reference = df_train$loan_status)

## Confusion Matrix and Statistics
##
##          true
## pred      Charged Off Fully Paid
## Charged Off      8366      89
## Fully Paid       1284    60262
##
##          Accuracy : 0.9804
##                 95% CI : (0.9793, 0.9814)
## No Information Rate : 0.8621
## P-Value [Acc > NIR] : < 2.2e-16
##
##          Kappa : 0.913
##
## McNemar's Test P-Value : < 2.2e-16
##
##          Sensitivity : 0.8669
##          Specificity : 0.9985
## Pos Pred Value : 0.9895
## Neg Pred Value : 0.9791
##          Prevalence : 0.1379
## Detection Rate : 0.1195
## Detection Prevalence : 0.1208
## Balanced Accuracy : 0.9327
##
## 'Positive' Class : Charged Off
##

#Findings :
# 1. Accuracy of the decision tree on training data is 86.5%
# 2. Sensitivity of the decision tree on training data is 0.067
# 3. Specificity of the decision tree on training data is 0.99

# Predicting the model on test data
df_table_test <- table(pred = predict(DT1,df_test, type='class'), true=df_test$loan_status)
df_table_test

##          true
## pred      Charged Off Fully Paid
## Charged Off      3552      58
## Fully Paid       583    25806

mean(predict(DT1,df_test, type='class') ==df_test$loan_status)

## [1] 0.9786326

```

```

# Findings : Accuracy is 85.5%

#Confusion Matrix for test data
confusionMatrix(df_table_test,reference = df_test$loan_status)

## Confusion Matrix and Statistics
##
##          true
## pred      Charged Off Fully Paid
## Charged Off      3552      58
## Fully Paid       583     25806
##
##          Accuracy : 0.9786
##                 95% CI : (0.9769, 0.9802)
## No Information Rate : 0.8622
## P-Value [Acc > NIR] : < 2.2e-16
##
##          Kappa : 0.905
##
## McNemar's Test P-Value : < 2.2e-16
##
##          Sensitivity : 0.8590
##          Specificity : 0.9978
## Pos Pred Value : 0.9839
## Neg Pred Value : 0.9779
##          Prevalence : 0.1378
## Detection Rate : 0.1184
## Detection Prevalence : 0.1203
## Balanced Accuracy : 0.9284
##
## 'Positive' Class : Charged Off
##

#Findings :
# 1. Accuracy of the decision tree on training data is 85.5%
# 2. Sensitivity of the decision tree on training data is 0.036
# 3. Specificity of the decision tree on training data is 0.989

library(ROCR)
# Function to find lift, ROC curve and AUC value
fnROCPerformance <- function(scores, data) {pred=prediction(scores, data$loan_status, label.ordering =
  #ROC curve
  aucPerf <- performance(pred, "tpr", "fpr")
  plot(aucPerf)
  abline(a=0, b= 1)

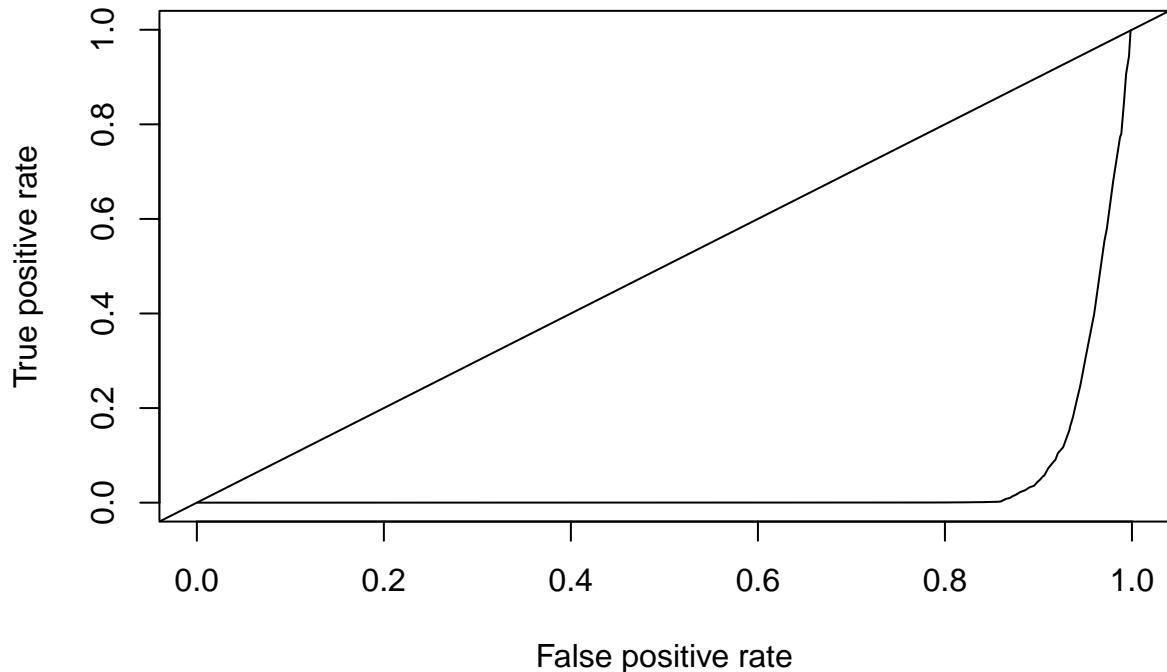
  #AUC value
  aucPerf=performance(pred, "auc")
  sprintf("AUC: %f", aucPerf@y.values)

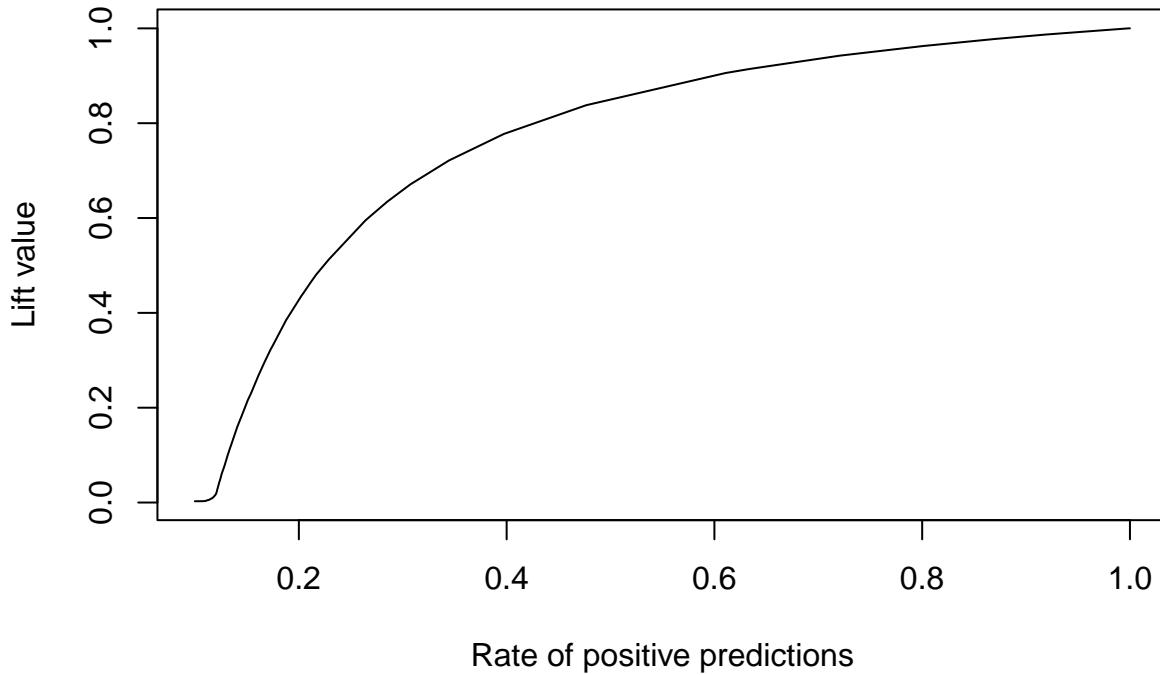
  #Lift curve
  liftPerf <- performance(pred, "lift", "rpp")

```

```
plot(liftPerf)
}

fnROCPerformance(score=predict(DT1,df_test, type="prob")[, "Charged Off"],df_test)
```





```

# AUC : 0.35

# Decile lift performance, for minority class (Charged Off")
fnDecileLiftsPerformance_defaults <- function( scores, dat) {
  totDefRate= sum(dat$loan_status=="Charged Off")/nrow(dat)
  decPerf <- data.frame(scores)
  decPerf <- cbind(decPerf, status=dat$loan_status, grade=dat$grade)
  decPerf <- decPerf %>% mutate(decile = ntile(-scores, 10))
  decPerf<- decPerf %>% group_by(decile) %>% summarise (
    count=n(), numDefaults=sum(status=="Charged Off"), defaultRate=numDefaults/count,
    totA=sum(grade=="A"), totB=sum(grade=="B" ), totC=sum(grade=="C"), totD=sum(grade=="D"),
    totE=sum(grade=="E"), totF=sum(grade=="F" ) )
  decPerf$cumDefaults=cumsum(decPerf$numDefaults)
  decPerf$cumDefaultRate=decPerf$cumDefaults/cumsum(decPerf$count)
  decPerf$cumDefaultLift<- decPerf$cumDefaultRate/(sum(decPerf$numDefaults)/sum(decPerf$count))

  print(decPerf)
}

fnDecileLiftsPerformance_defaults(score=predict(DT1,df_test, type="prob")[, "Charged Off"], df_test)

## # A tibble: 10 x 13
##   decile count numDefaults defaul~1  totA  totB  totC  totD  totE  totF cumDe~2
##       <int> <int>      <int>    <dbl> <int> <int> <int> <int> <int> <int>      <int>
## 1       1     3000      2993  0.998     267    897   1019    567    211     35    2993
## 2       2     3000      793  0.264     260    941    952    588    209     47    3786

```

```

## 3      3 3000          93 0.031      535 999 920 390 130 26 3879
## 4      4 3000          53 0.0177     484 1004 939 438 104 25 3932
## 5      5 3000          46 0.0153     777 1190 667 312 48 5 3978
## 6      6 3000          31 0.0103     862 1060 720 267 80 11 4009
## 7      7 3000          37 0.0123     796 1070 695 339 82 17 4046
## 8      8 3000          36 0.012      717 1103 788 311 70 10 4082
## 9      9 3000          23 0.00767    887 944 746 332 74 16 4105
## 10     10 2999         30 0.0100     1204 989 526 215 57 8 4135
## # ... with 2 more variables: cumDefaultRate <dbl>, cumDefaultLift <dbl>, and
## #   abbreviated variable names 1: defaultRate, 2: cumDefaults

```

6 question

Random forest Model

```

library(ranger)
library(caret)

TRNFRACTION = 0.7
#Doing a 70-30 split between training and test subsets
nr<-nrow(df_final)

trnIndex<- sample(1:nr, size = round(TRNFRACTION * nr), replace=FALSE)
rfTrn <- df_final[trnIndex, ]
rfTst <- df_final[-trnIndex, ]

rgModel1 <- ranger(as.factor(loan_status)~., data=rfTrn %>% select(-all_of(vars0mit)),num.trees =50,imp

# Predicting the random forest model on train data
scoreTrn <- predict(rgModel1,rfTrn)
a<-table(rfTrn$loan_status,predictions(scoreTrn))
confusionMatrix(a)

## Confusion Matrix and Statistics
##
##
##          Charged Off Fully Paid
## Charged Off      9678        4
## Fully Paid        0      60318
##
##          Accuracy : 0.9999
##             95% CI : (0.9999, 1)
##   No Information Rate : 0.8617
##   P-Value [Acc > NIR] : <2e-16
##
##          Kappa : 0.9998
##
## Mcnemar's Test P-Value : 0.1336
##
##          Sensitivity : 1.0000

```

```

##          Specificity : 0.9999
##      Pos Pred Value : 0.9996
##      Neg Pred Value : 1.0000
##          Prevalence : 0.1383
##      Detection Rate : 0.1383
## Detection Prevalence : 0.1383
##      Balanced Accuracy : 1.0000
##
##      'Positive' Class : Charged Off
##

rgModel1$prediction.error

## [1] 0.06534286

# Accuracy : 99.9% on the train data

# Predicting the random forest model on test data
scoreTst <- predict(rgModel1,rfTst)
a<-table(rfTst$loan_status,predictions(scoreTst))
confusionMatrix(a)

## Confusion Matrix and Statistics
##
##
##          Charged Off Fully Paid
##      Charged Off     2206      1897
##      Fully Paid        4     25893
##
##          Accuracy : 0.9366
##          95% CI : (0.9338, 0.9394)
##      No Information Rate : 0.9263
##      P-Value [Acc > NIR] : 1.579e-12
##
##          Kappa : 0.667
##
##      Mcnemar's Test P-Value : < 2.2e-16
##
##          Sensitivity : 0.99819
##          Specificity : 0.93174
##      Pos Pred Value : 0.53766
##      Neg Pred Value : 0.99985
##          Prevalence : 0.07367
##      Detection Rate : 0.07353
## Detection Prevalence : 0.13677
##      Balanced Accuracy : 0.96496
##
##      'Positive' Class : Charged Off
##

```

```
rgModel1$prediction.error
```

```
## [1] 0.06534286
```

```

#We got an accuracy of 86.1% on the test set

#Try over and under sampling
library(ROSE)

## Loaded ROSE 0.0-4

data_balanced_over <- ovun.sample(loan_status ~ ., data =rfTrn %>% select(-all_of(vars0mit)), method =
rgModel<- ranger(formula = as.factor(loan_status)~.,data = data_balanced_over,num.trees=50,importance = TRUE)

## Computing permutation importance.. Progress: 66%. Estimated remaining time: 17 seconds.

scoreTst <- predict(rgModel,rfTst)
a<-table(rfTst$loan_status,predictions(scoreTst))
rgModel$prediction.error

## [1] 0.006515789

# Accuracy : 85.9%
#Even with oversampling, the model is not able to predict the charged off loans very well.

#variable importance comparison
print("Random Forest Model 1")

## [1] "Random Forest Model 1"

sort(rgModel1$variable.importance, decreasing = TRUE)

##          total_pymnt           installment
## 1.955927e-01 7.977892e-02
##          loan_amnt          tot_hi_cred_lim
## 7.580634e-02 1.393920e-02
##          tot_cur_bal          avg_cur_bal
## 1.251113e-02 1.011961e-02
##          sub_grade         bc_open_to_buy
## 9.199115e-03 8.897625e-03
##          int_rate        total_bc_limit
## 8.896465e-03 8.844165e-03
##          total_rev_hi_lim          revol_bal
## 8.244152e-03 6.716723e-03
##          annual_inc       total_bal_ex_mort
## 6.273563e-03 5.957870e-03
##          bc_util                  grade
## 5.828036e-03 5.152334e-03
##          borrrHistory    percent_bc_gt_75
## 4.991619e-03 4.923220e-03
##          earliest_cr_line          revol_util
## 4.159657e-03 4.139066e-03
##          num_rev_tl_bal_gt_0      acc_open_past_24mths

```

```

##          4.051309e-03          3.905663e-03
##      mo_sin_old_rev_tl_op      num_actv_rev_tl
##          3.905629e-03          3.801214e-03
##  total_il_high_credit_limit      total_acc
##          3.529170e-03          3.273571e-03
##      num_op_rev_tl      num_rev_accts
##          3.198764e-03          2.745802e-03
##      open_acc      mo_sin_rcnt_rev_tl_op
##          2.386536e-03          2.329432e-03
##      num_actv_bc_tl      num_tl_op_past_12m
##          2.279843e-03          2.277433e-03
##      num_sats      num_bc_tl
##          2.236166e-03          2.224566e-03
##      mort_acc      dti
##          2.180676e-03          2.146867e-03
##      num_bc_sats      mo_sin_rcnt_tl
##          2.078531e-03          2.050248e-03
##  home_ownership      num_il_tl
##          1.768565e-03          1.642340e-03
##  mths_since_recent_bc      mo_sin_old_il_acct
##          1.559617e-03          1.282323e-03
##      pct_tl_nvr_dlq      mths_since_last_delinq
##          9.204753e-04          7.662751e-04
##  mths_since_recent_bc_dlq  mths_since_recent_revol_delinq
##          6.762553e-04          6.254358e-04
##      inq_last_6mths      purpose
##          6.065372e-04          4.776247e-04
##  mths_since_recent_inq      verification_status
##          4.765497e-04          4.738503e-04
##  mths_since_last_major_derog      delinq_2yrs
##          4.051808e-04          3.242703e-04
##      num_accts_ever_120_pd      pub_rec_bankruptcies
##          2.011049e-04          1.815637e-04
##      tot_coll_amt      addr_state
##          1.280216e-04          1.157863e-04
##      num_tl_90g_dpd_24m      initial_list_status
##          1.040062e-04          5.207810e-05
##      pub_rec      mths_since_last_record
##          3.647563e-05          3.010968e-05
##      tax_liens      delinq_amnt
##          2.874826e-05          2.094138e-05
##  collections_12_mths_ex_med      acc_now_delinq
##          1.089867e-05          5.402657e-06
##      num_tl_30dpd      num_tl_120dpd_2m
##          7.820503e-07          7.705291e-07
##      pymnt_plan      chargeoff_within_12_mths
##          0.000000e+00          -2.304974e-06

```

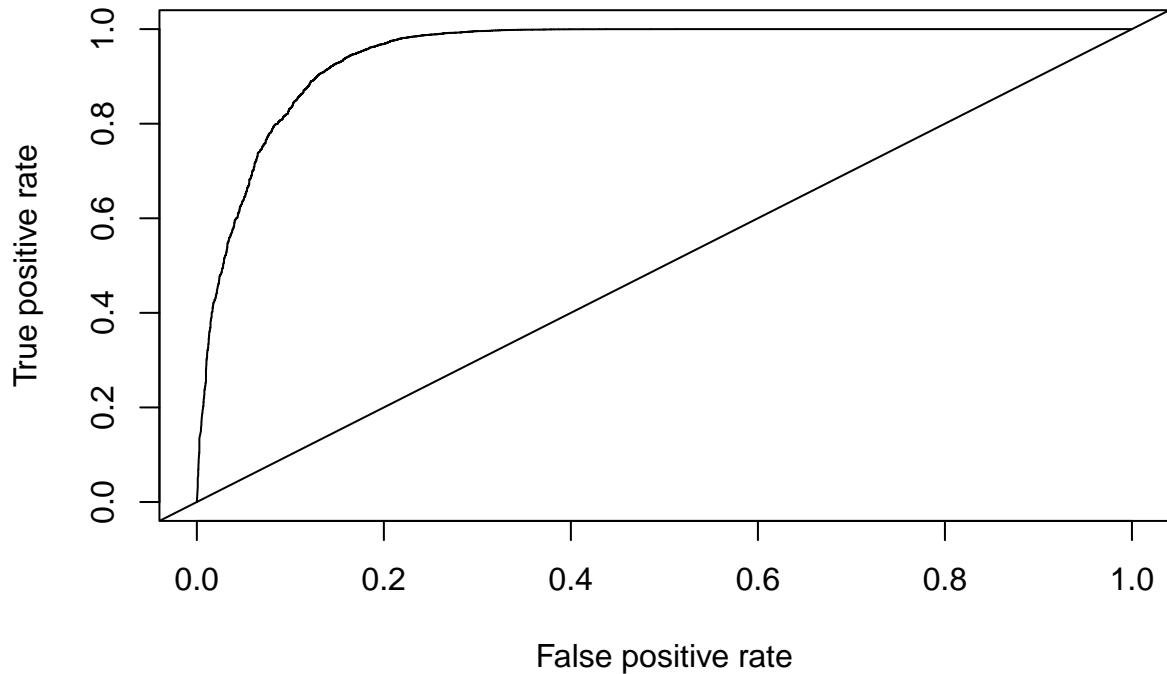
##Identitical to rgModel2 but with probabilities

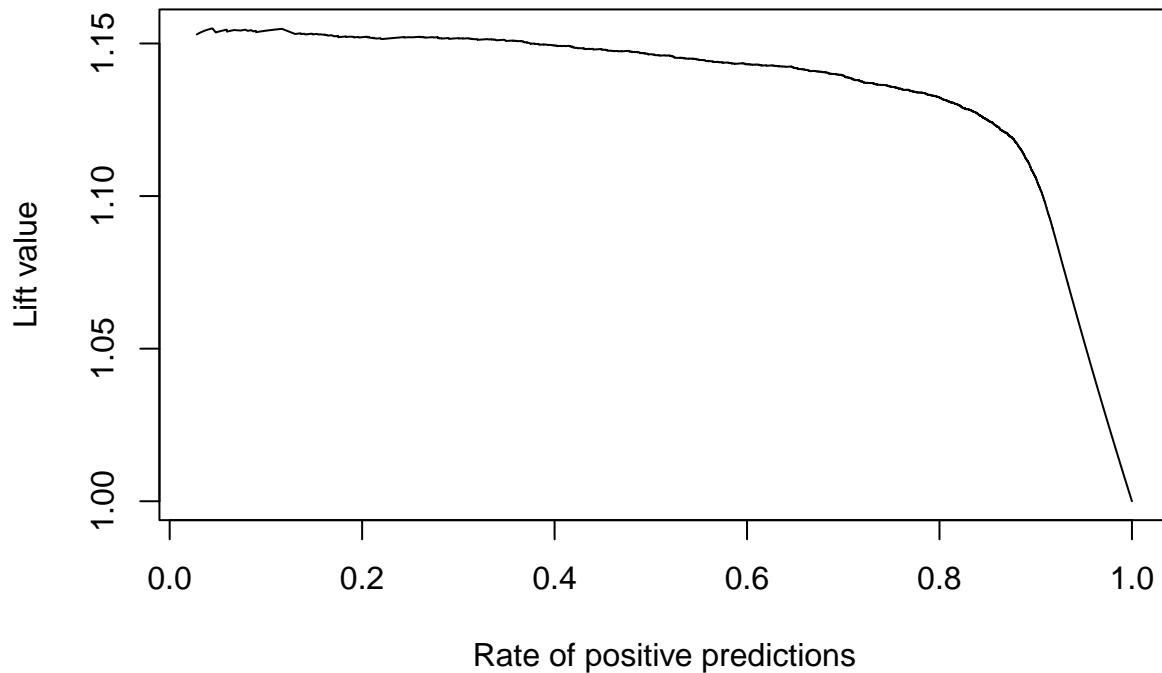
#Plotting the AUC Curve

```
rgModel3 <- ranger(as.factor(loan_status) ~ ., data=rfTrn %>% select(-all_of(vars0mit)), num.trees = 50,
```

To find the ROC,AUC and lift plot

```
fnROCPeformance(predict(rgModel3,rfTst)$predictions[, "Fully Paid"], rfTst)
```





```
#for decile defaults-lift performance
fnDecileLiftsPerformance_defaults( predict(rgModel3,rfTst)$predictions[, "Charged Off"], rfTst)

## # A tibble: 10 x 13
##   decile count numDefaults default~1 totA totB totC totD totE totF cumDe~2
##   <int> <int>      <int>     <dbl> <int> <int> <int> <int> <int> <int> <int>
## 1      1    3000      2882  0.961     213    726   1056   686   246    67    2882
## 2      2    3000       679  0.226     159    616   1009   783   322    98    3561
## 3      3    3000      198  0.066     182    752   1139   678   218    31    3759
## 4      4    3000      107  0.0357    282    888   1146   534   140     10    3866
## 5      5    3000       82  0.0273    366   1127   1011   421    72     3    3948
## 6      6    3000       61  0.0203    532   1258   878    298    34     0    4009
## 7      7    3000       42  0.014     711   1397   704    168    20     0    4051
## 8      8    3000       19  0.00633   1028  1337   510    113    12     0    4070
## 9      9    3000       22  0.00733   1409  1225   305    57     4     0    4092
## 10    10   3000        11  0.00367  1948   889   144    19     0     0    4103
## # ... with 2 more variables: cumDefaultRate <dbl>, cumDefaultLift <dbl>, and
## #   abbreviated variable names 1: defaultRate, 2: cumDefaults
```

6th question

XGboost

```
library(xgboost)

## 
## Attaching package: 'xgboost'

## The following object is masked from 'package:dplyr':
## 
##     slice

#Needs all data to be numeric -- so we convert categorical (i.e. factor) variables using one-hot encoding
sapply(lapply(df_final, unique), length)

##          loan_amnt           int_rate
##                   1270                  194
##          installment           grade
##                   21087                  7
##          sub_grade           home_ownership
##                   35                  3
##          annual_inc           verification_status
##                   8834                  3
##          loan_status           pymnt_plan
##                   2                  1
##          purpose             addr_state
##                   13                  49
##          dti                 delinq_2yrs
##                   3974                  21
##          earliest_cr_line        inq_last_6mths
##                   628                  7
##          mths_since_last_delinq   mths_since_last_record
##                   118                  120
##          open_acc              pub_rec
##                   57                  17
##          revol_bal             revol_util
##                   35262                 1096
##          total_acc            initial_list_status
##                   104                  2
##          total_pymnt           last_pymnt_d
##                   96673                  74
##          collections_12_mths_ex_med   mths_since_last_major_derog
##                   7                  130
##          acc_now_delinq           tot_coll_amt
##                   5                  3710
##          tot_cur_bal            total_rev_hi_lim
##                   80199                 4779
##          acc_open_past_24mths        avg_cur_bal
##                   35                  33350
```

```

##          bc_open_to_buy           bc_util
##                      27523                  1169
##          chargeoff_within_12_mths      delinq_amnt
##                               7                   296
##          mo_sin_old_il_acct       mo_sin_old_rev_tl_op
##                               431                  651
##          mo_sin_rcnt_rev_tl_op     mo_sin_rcnt_tl
##                               182                  128
##          mort_acc                mths_since_recent_bc
##                               25                  329
##          mths_since_recent_bc_dlq   mths_since_recent_inq
##                               115                  25
##          mths_since_recent_revol_delinq num_accts_ever_120_pd
##                               121                  21
##          num_actv_bc_tl            num_actv_rev_tl
##                               27                  38
##          num_bc_sats              num_bc_tl
##                               35                  49
##          num_il_tl                num_op_rev_tl
##                               80                  51
##          num_rev_accts            num_rev_tl_bal_gt_0
##                               79                  36
##          num_sats                 num_tl_120dpd_2m
##                               58                  3
##          num_tl_30dpd              num_tl_90g_dpd_24m
##                               5                  19
##          num_tl_op_past_12m        pct_tl_nvr_dlq
##                               26                  427
##          percent_bc_gt_75          pub_rec_bankruptcies
##                               149                  9
##          tax_liens                tot_hi_cred_lim
##                               15                  76534
##          total_bal_ex_mort         total_bc_limit
##                               62154                  3161
##          total_il_high_credit_limit actual_term
##                               52497                  186
##          actual_return            propSatisBankcardAccts
##                               97179                  332
##          borrHistory              openAccRatio
##                               2172                  1121

```

```

df_xg <- df_final %>% select(-pymnt_plan,initial_list_status)

# use the dummyVars function in the 'caret' package to convert factor variables to # dummy-variables
fdum <-dummyVars(~.,data=df_xg %>% select(-loan_status)) #do not include loan_status for this
dxlcdf <- predict(fdum, df_xg)
# for loan_status, check levels and convert to dummy vars and keep the class label of interest
#levels(lcdf$loan_status)
dylcdf <- class2ind(as.factor(df_xg$loan_status), drop2nd = FALSE)
# and then decide which one to keep
fplcdf <- dylcdf [ , 1] # or,
colcdf <- dylcdf [ , 2]
#Training, test subsets
dxlcdfTrn <- dxlcdf[trnIndex,]

```

```

colcdfTrn <- colcdf[trnIndex]
dxlcdfTst <- dxlcdf[-trnIndex,]
colcdfTst <- colcdf[-trnIndex]
dxTrn <- xgb.DMatrix(dxlcdfTrn, label=colcdfTrn)
dxTst <- xgb.DMatrix(dxlcdfTst, label=colcdfTst)
#dxTst <- xgb.DMatrix( subset( dxlcdfTst, select = -c( actual_term, actual_return, total_pymnt)), label=colcdfTst)
xgbWatchlist <- list(train = dxTrn, eval = dxTst)
#we can watch the progress of learning thru performance on these datasets
#list of parameters for the xgboost model development functions
xgbParam <- list (
  max_depth = 5, eta = 0.01,
  objective = "binary:logistic",
  eval_metric="error", eval_metric = "auc")
#can specify which evaluation metrics we want to watch
xgb_lsM1 <- xgb.train( xgbParam, dxTrn, nrounds = 500,
xgbWatchlist, early_stopping_rounds = 10 )

## [1] train-error:0.000000    train-auc:1.000000  eval-error:0.000033 eval-auc:0.999980
## Multiple eval metrics are present. Will use eval_auc for early stopping.
## Will train until eval_auc hasn't improved in 10 rounds.
##
## [2] train-error:0.000000    train-auc:1.000000  eval-error:0.000033 eval-auc:0.999980
## [3] train-error:0.000000    train-auc:1.000000  eval-error:0.000033 eval-auc:0.999980
## [4] train-error:0.000000    train-auc:1.000000  eval-error:0.000033 eval-auc:0.999980
## [5] train-error:0.000000    train-auc:1.000000  eval-error:0.000033 eval-auc:0.999980
## [6] train-error:0.000000    train-auc:1.000000  eval-error:0.000033 eval-auc:0.999980
## [7] train-error:0.000000    train-auc:1.000000  eval-error:0.000033 eval-auc:0.999980
## [8] train-error:0.000000    train-auc:1.000000  eval-error:0.000033 eval-auc:0.999980
## [9] train-error:0.000000    train-auc:1.000000  eval-error:0.000033 eval-auc:0.999980
## [10] train-error:0.000000   train-auc:1.000000  eval-error:0.000033 eval-auc:0.999980
## [11] train-error:0.000000   train-auc:1.000000  eval-error:0.000033 eval-auc:0.999980
## Stopping. Best iteration:
## [1] train-error:0.000000    train-auc:1.000000  eval-error:0.000033 eval-auc:0.999980

xgb_lsM1$best_iteration

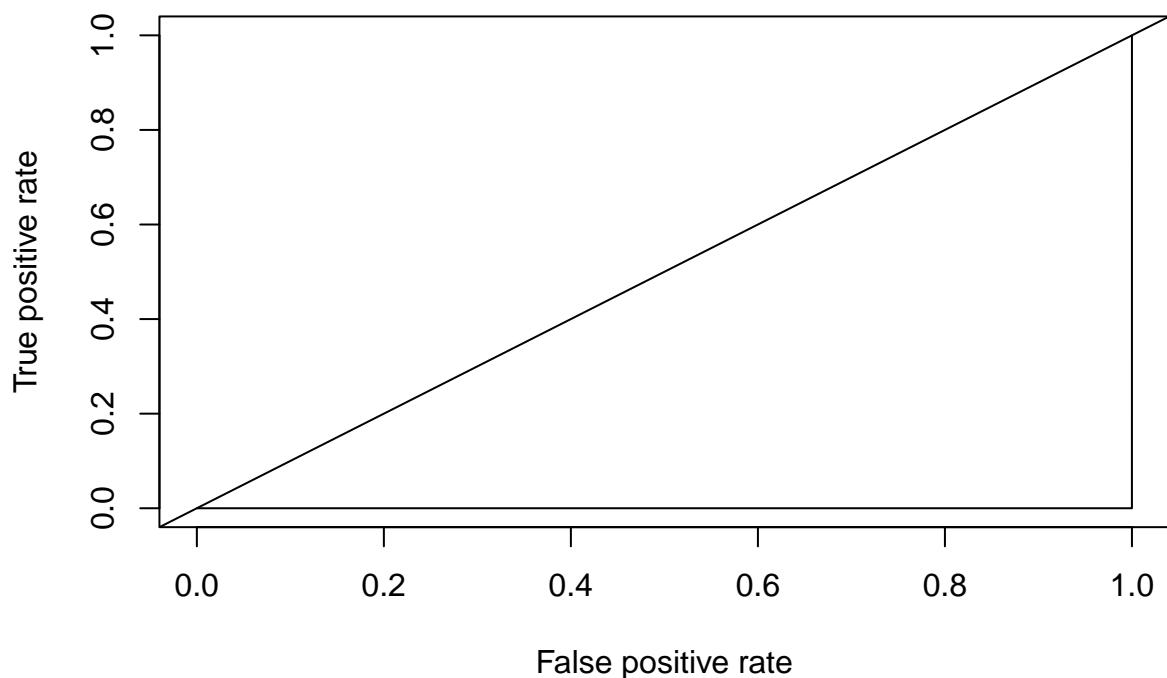
## [1] 1

xpredTrg<-predict(xgb_lsM1, dxTrn)
head(xpredTrg)

## [1] 0.5049989 0.4950024 0.5049993 0.5049993 0.4950024 0.4950024

xpredTst<-predict(xgb_lsM1, dxTst)
pred_xgb_lsM1=prediction(xpredTst,rfTst$loan_status,label.ordering = c("Fully Paid", "Charged Off"))
aucPerf_xgb_lsM1=performance(pred_xgb_lsM1, "tpr", "fpr")
plot(aucPerf_xgb_lsM1)
abline(a=0, b= 1)

```



```
plot.new()
```

```

#use cross-validation on training dataset to determine best model
xgbParam <- list (
  max_depth = 3, eta = 0.1,
  objective = "binary:logistic",
  eval_metric="error", eval_metric = "auc")
xgb_lscv <- xgb.cv( xgbParam, dxTrn, nrounds = 500, nfold=5, early_stopping_rounds = 10 )

## [1] train-error:0.000018+0.000016  train-auc:0.999998+0.000004 test-error:0.000071+0.000045
## Multiple eval metrics are present. Will use test_auc for early stopping.
## Will train until test_auc hasn't improved in 10 rounds.
##
## [2] train-error:0.000011+0.000014  train-auc:1.000000+0.000000 test-error:0.000057+0.000029
## [3] train-error:0.000007+0.000014  train-auc:1.000000+0.000000 test-error:0.000029+0.000035
## [4] train-error:0.000007+0.000014  train-auc:1.000000+0.000000 test-error:0.000029+0.000035
## [5] train-error:0.000007+0.000014  train-auc:1.000000+0.000000 test-error:0.000029+0.000035
## [6] train-error:0.000007+0.000014  train-auc:1.000000+0.000000 test-error:0.000029+0.000035
## [7] train-error:0.000007+0.000014  train-auc:1.000000+0.000000 test-error:0.000029+0.000035
## [8] train-error:0.000004+0.000007  train-auc:1.000000+0.000000 test-error:0.000029+0.000035
## [9] train-error:0.000004+0.000007  train-auc:1.000000+0.000000 test-error:0.000029+0.000035
## [10] train-error:0.000004+0.000007 train-auc:1.000000+0.000000 test-error:0.000029+0.000035
## [11] train-error:0.000004+0.000007 train-auc:1.000000+0.000000 test-error:0.000029+0.000035
## [12] train-error:0.000004+0.000007 train-auc:1.000000+0.000000 test-error:0.000029+0.000035
## Stopping. Best iteration:
## [2] train-error:0.000011+0.000014  train-auc:1.000000+0.000000 test-error:0.000057+0.000029

```

```

#best iteration
xgb_lscv$best_iteration

## [1] 2

# or for the best iteration based on performance measure (among those specified in xgbParam)
best_cvIter <- which.max(xgb_lscv$evaluation_log$test_auc_mean)
#which.min(xgb_lscv$evaluation_log$test_error_mean)
#best model
xgb_lsbest <- xgb.train( xgbParam, dxTrn, nrounds = xgb_lscv$best_iteration )
#variable importance
xgb.importance(model = xgb_lsbest) %>% view()

xgbParamGrid <- expand.grid(
max_depth = c(2, 5),
eta = c(0.001, 0.01, 0.1) )
xgbParamGrid

##   max_depth eta
## 1          2 0.001
## 2          5 0.001
## 3          2 0.010
## 4          5 0.010
## 5          2 0.100
## 6          5 0.100

xgbParam <- list (
booster = "gbtree",
objective ="binary:logistic",
#eta=0.01, #learning rate
#max_depth=5,
min_child_weight=1,
colsample_bytree=0.6
)

for(i in 1:nrow(xgbParamGrid)) {
xgb_tune<- xgb.train(data=dxTrn,xgbParam,
nrounds=1000, early_stopping_rounds = 10, xgbWatchlist,
eta=xgbParamGrid$eta[i], max_depth=xgbParamGrid$max_depth[i] )
xgbParamGrid$bestTree[i] <- xgb_tune$evaluation_log[xgb_tune$best_iteration]$iter
xgbParamGrid$bestPerf[i] <- xgb_tune$evaluation_log[xgb_tune$best_iteration]$eval_auc
}

## [1] train-logloss:0.692182 eval-logloss:0.692181
## Multiple eval metrics are present. Will use eval_logloss for early stopping.
## Will train until eval_logloss hasn't improved in 10 rounds.
##
## [2] train-logloss:0.691633 eval-logloss:0.691632
## [3] train-logloss:0.690671 eval-logloss:0.690669
## [4] train-logloss:0.690019 eval-logloss:0.690014
## [5] train-logloss:0.689059 eval-logloss:0.689054
## [6] train-logloss:0.688406 eval-logloss:0.688400

```

```

## [7] train-logloss:0.687755 eval-logloss:0.687747
## [8] train-logloss:0.686766 eval-logloss:0.686758
## [9] train-logloss:0.685813 eval-logloss:0.685805
## [10] train-logloss:0.684829 eval-logloss:0.684820
## [11] train-logloss:0.683879 eval-logloss:0.683871
## [12] train-logloss:0.682932 eval-logloss:0.682923
## [13] train-logloss:0.681994 eval-logloss:0.681985
## [14] train-logloss:0.681051 eval-logloss:0.681041
## [15] train-logloss:0.680117 eval-logloss:0.680106
## [16] train-logloss:0.679185 eval-logloss:0.679174
## [17] train-logloss:0.678247 eval-logloss:0.678235
## [18] train-logloss:0.677277 eval-logloss:0.677266
## [19] train-logloss:0.676342 eval-logloss:0.676331
## [20] train-logloss:0.675376 eval-logloss:0.675365
## [21] train-logloss:0.674412 eval-logloss:0.674401
## [22] train-logloss:0.673483 eval-logloss:0.673472
## [23] train-logloss:0.672556 eval-logloss:0.672544
## [24] train-logloss:0.671631 eval-logloss:0.671619
## [25] train-logloss:0.670715 eval-logloss:0.670702
## [26] train-logloss:0.669801 eval-logloss:0.669788
## [27] train-logloss:0.668889 eval-logloss:0.668875
## [28] train-logloss:0.668323 eval-logloss:0.668308
## [29] train-logloss:0.667414 eval-logloss:0.667398
## [30] train-logloss:0.666499 eval-logloss:0.666482
## [31] train-logloss:0.665552 eval-logloss:0.665536
## [32] train-logloss:0.664607 eval-logloss:0.664591
## [33] train-logloss:0.663664 eval-logloss:0.663648
## [34] train-logloss:0.662756 eval-logloss:0.662739
## [35] train-logloss:0.662139 eval-logloss:0.662121
## [36] train-logloss:0.661201 eval-logloss:0.661183
## [37] train-logloss:0.660265 eval-logloss:0.660246
## [38] train-logloss:0.659330 eval-logloss:0.659312
## [39] train-logloss:0.658430 eval-logloss:0.658411
## [40] train-logloss:0.657532 eval-logloss:0.657513
## [41] train-logloss:0.656635 eval-logloss:0.656616
## [42] train-logloss:0.656094 eval-logloss:0.656073
## [43] train-logloss:0.655553 eval-logloss:0.655530
## [44] train-logloss:0.654668 eval-logloss:0.654645
## [45] train-logloss:0.653785 eval-logloss:0.653761
## [46] train-logloss:0.652895 eval-logloss:0.652871
## [47] train-logloss:0.652350 eval-logloss:0.652325
## [48] train-logloss:0.651849 eval-logloss:0.651823
## [49] train-logloss:0.650971 eval-logloss:0.650944
## [50] train-logloss:0.650095 eval-logloss:0.650067
## [51] train-logloss:0.649213 eval-logloss:0.649185
## [52] train-logloss:0.648615 eval-logloss:0.648586
## [53] train-logloss:0.647703 eval-logloss:0.647674
## [54] train-logloss:0.646833 eval-logloss:0.646803
## [55] train-logloss:0.645924 eval-logloss:0.645894
## [56] train-logloss:0.645017 eval-logloss:0.644987
## [57] train-logloss:0.644111 eval-logloss:0.644082
## [58] train-logloss:0.643248 eval-logloss:0.643218
## [59] train-logloss:0.642386 eval-logloss:0.642355
## [60] train-logloss:0.641518 eval-logloss:0.641487

```

```

## [61] train-logloss:0.640619 eval-logloss:0.640589
## [62] train-logloss:0.639762 eval-logloss:0.639731
## [63] train-logloss:0.638867 eval-logloss:0.638836
## [64] train-logloss:0.638386 eval-logloss:0.638354
## [65] train-logloss:0.637526 eval-logloss:0.637493
## [66] train-logloss:0.636667 eval-logloss:0.636635
## [67] train-logloss:0.635810 eval-logloss:0.635777
## [68] train-logloss:0.634922 eval-logloss:0.634889
## [69] train-logloss:0.634069 eval-logloss:0.634035
## [70] train-logloss:0.633224 eval-logloss:0.633190
## [71] train-logloss:0.632373 eval-logloss:0.632339
## [72] train-logloss:0.631524 eval-logloss:0.631490
## [73] train-logloss:0.630677 eval-logloss:0.630642
## [74] train-logloss:0.629831 eval-logloss:0.629796
## [75] train-logloss:0.629262 eval-logloss:0.629225
## [76] train-logloss:0.628419 eval-logloss:0.628381
## [77] train-logloss:0.627944 eval-logloss:0.627906
## [78] train-logloss:0.627111 eval-logloss:0.627072
## [79] train-logloss:0.626272 eval-logloss:0.626233
## [80] train-logloss:0.625435 eval-logloss:0.625395
## [81] train-logloss:0.624606 eval-logloss:0.624566
## [82] train-logloss:0.623779 eval-logloss:0.623738
## [83] train-logloss:0.622946 eval-logloss:0.622905
## [84] train-logloss:0.622122 eval-logloss:0.622081
## [85] train-logloss:0.621259 eval-logloss:0.621218
## [86] train-logloss:0.620438 eval-logloss:0.620397
## [87] train-logloss:0.619612 eval-logloss:0.619570
## [88] train-logloss:0.619053 eval-logloss:0.619010
## [89] train-logloss:0.618229 eval-logloss:0.618186
## [90] train-logloss:0.617414 eval-logloss:0.617370
## [91] train-logloss:0.616600 eval-logloss:0.616555
## [92] train-logloss:0.615780 eval-logloss:0.615735
## [93] train-logloss:0.614962 eval-logloss:0.614917
## [94] train-logloss:0.614410 eval-logloss:0.614363
## [95] train-logloss:0.613562 eval-logloss:0.613515
## [96] train-logloss:0.612755 eval-logloss:0.612708
## [97] train-logloss:0.611942 eval-logloss:0.611895
## [98] train-logloss:0.611394 eval-logloss:0.611346
## [99] train-logloss:0.610584 eval-logloss:0.610536
## [100] train-logloss:0.609783 eval-logloss:0.609734
## [101] train-logloss:0.608943 eval-logloss:0.608894
## [102] train-logloss:0.608451 eval-logloss:0.608401
## [103] train-logloss:0.607654 eval-logloss:0.607603
## [104] train-logloss:0.606857 eval-logloss:0.606807
## [105] train-logloss:0.606023 eval-logloss:0.605973
## [106] train-logloss:0.605483 eval-logloss:0.605431
## [107] train-logloss:0.604651 eval-logloss:0.604599
## [108] train-logloss:0.604116 eval-logloss:0.604062
## [109] train-logloss:0.603326 eval-logloss:0.603271
## [110] train-logloss:0.602498 eval-logloss:0.602444
## [111] train-logloss:0.601963 eval-logloss:0.601907
## [112] train-logloss:0.601431 eval-logloss:0.601374
## [113] train-logloss:0.600646 eval-logloss:0.600588
## [114] train-logloss:0.600114 eval-logloss:0.600055

```

```

## [115] train-logloss:0.599324 eval-logloss:0.599265
## [116] train-logloss:0.598794 eval-logloss:0.598733
## [117] train-logloss:0.598014 eval-logloss:0.597953
## [118] train-logloss:0.597228 eval-logloss:0.597167
## [119] train-logloss:0.596411 eval-logloss:0.596350
## [120] train-logloss:0.595596 eval-logloss:0.595535
## [121] train-logloss:0.594815 eval-logloss:0.594753
## [122] train-logloss:0.594042 eval-logloss:0.593980
## [123] train-logloss:0.593576 eval-logloss:0.593513
## [124] train-logloss:0.592805 eval-logloss:0.592742
## [125] train-logloss:0.591997 eval-logloss:0.591933
## [126] train-logloss:0.591228 eval-logloss:0.591165
## [127] train-logloss:0.590455 eval-logloss:0.590391
## [128] train-logloss:0.589690 eval-logloss:0.589625
## [129] train-logloss:0.589171 eval-logloss:0.589106
## [130] train-logloss:0.588402 eval-logloss:0.588336
## [131] train-logloss:0.587640 eval-logloss:0.587574
## [132] train-logloss:0.586873 eval-logloss:0.586806
## [133] train-logloss:0.586075 eval-logloss:0.586008
## [134] train-logloss:0.585310 eval-logloss:0.585244
## [135] train-logloss:0.584554 eval-logloss:0.584487
## [136] train-logloss:0.584043 eval-logloss:0.583975
## [137] train-logloss:0.583250 eval-logloss:0.583182
## [138] train-logloss:0.582740 eval-logloss:0.582671
## [139] train-logloss:0.581950 eval-logloss:0.581880
## [140] train-logloss:0.581199 eval-logloss:0.581130
## [141] train-logloss:0.580741 eval-logloss:0.580670
## [142] train-logloss:0.579986 eval-logloss:0.579915
## [143] train-logloss:0.579566 eval-logloss:0.579494
## [144] train-logloss:0.578820 eval-logloss:0.578748
## [145] train-logloss:0.578068 eval-logloss:0.577996
## [146] train-logloss:0.577286 eval-logloss:0.577214
## [147] train-logloss:0.576537 eval-logloss:0.576465
## [148] train-logloss:0.575758 eval-logloss:0.575685
## [149] train-logloss:0.575012 eval-logloss:0.574939
## [150] train-logloss:0.574610 eval-logloss:0.574535
## [151] train-logloss:0.573834 eval-logloss:0.573759
## [152] train-logloss:0.573059 eval-logloss:0.572984
## [153] train-logloss:0.572286 eval-logloss:0.572211
## [154] train-logloss:0.571514 eval-logloss:0.571439
## [155] train-logloss:0.570775 eval-logloss:0.570700
## [156] train-logloss:0.570044 eval-logloss:0.569969
## [157] train-logloss:0.569641 eval-logloss:0.569565
## [158] train-logloss:0.568912 eval-logloss:0.568835
## [159] train-logloss:0.568185 eval-logloss:0.568107
## [160] train-logloss:0.567452 eval-logloss:0.567374
## [161] train-logloss:0.566720 eval-logloss:0.566642
## [162] train-logloss:0.565996 eval-logloss:0.565918
## [163] train-logloss:0.565267 eval-logloss:0.565189
## [164] train-logloss:0.564546 eval-logloss:0.564467
## [165] train-logloss:0.563819 eval-logloss:0.563740
## [166] train-logloss:0.563062 eval-logloss:0.562984
## [167] train-logloss:0.562578 eval-logloss:0.562498
## [168] train-logloss:0.562189 eval-logloss:0.562107

```

```

## [169] train-logloss:0.561473 eval-logloss:0.561390
## [170] train-logloss:0.560751 eval-logloss:0.560669
## [171] train-logloss:0.560038 eval-logloss:0.559955
## [172] train-logloss:0.559288 eval-logloss:0.559205
## [173] train-logloss:0.558570 eval-logloss:0.558487
## [174] train-logloss:0.557822 eval-logloss:0.557740
## [175] train-logloss:0.557425 eval-logloss:0.557342
## [176] train-logloss:0.556711 eval-logloss:0.556627
## [177] train-logloss:0.556005 eval-logloss:0.555920
## [178] train-logloss:0.555293 eval-logloss:0.555208
## [179] train-logloss:0.554589 eval-logloss:0.554504
## [180] train-logloss:0.553880 eval-logloss:0.553795
## [181] train-logloss:0.553171 eval-logloss:0.553086
## [182] train-logloss:0.552465 eval-logloss:0.552379
## [183] train-logloss:0.551759 eval-logloss:0.551673
## [184] train-logloss:0.551023 eval-logloss:0.550937
## [185] train-logloss:0.550288 eval-logloss:0.550203
## [186] train-logloss:0.549586 eval-logloss:0.549501
## [187] train-logloss:0.549171 eval-logloss:0.549083
## [188] train-logloss:0.548477 eval-logloss:0.548390
## [189] train-logloss:0.548089 eval-logloss:0.548001
## [190] train-logloss:0.547709 eval-logloss:0.547620
## [191] train-logloss:0.547012 eval-logloss:0.546922
## [192] train-logloss:0.546628 eval-logloss:0.546538
## [193] train-logloss:0.545939 eval-logloss:0.545848
## [194] train-logloss:0.545245 eval-logloss:0.545154
## [195] train-logloss:0.544551 eval-logloss:0.544460
## [196] train-logloss:0.543828 eval-logloss:0.543737
## [197] train-logloss:0.543144 eval-logloss:0.543052
## [198] train-logloss:0.542684 eval-logloss:0.542591
## [199] train-logloss:0.542001 eval-logloss:0.541909
## [200] train-logloss:0.541282 eval-logloss:0.541190
## [201] train-logloss:0.540596 eval-logloss:0.540503
## [202] train-logloss:0.539879 eval-logloss:0.539786
## [203] train-logloss:0.539195 eval-logloss:0.539102
## [204] train-logloss:0.538480 eval-logloss:0.538388
## [205] train-logloss:0.537805 eval-logloss:0.537712
## [206] train-logloss:0.537093 eval-logloss:0.537000
## [207] train-logloss:0.536414 eval-logloss:0.536320
## [208] train-logloss:0.536041 eval-logloss:0.535947
## [209] train-logloss:0.535363 eval-logloss:0.535269
## [210] train-logloss:0.534655 eval-logloss:0.534561
## [211] train-logloss:0.533948 eval-logloss:0.533855
## [212] train-logloss:0.533281 eval-logloss:0.533186
## [213] train-logloss:0.532833 eval-logloss:0.532737
## [214] train-logloss:0.532167 eval-logloss:0.532071
## [215] train-logloss:0.531502 eval-logloss:0.531406
## [216] train-logloss:0.530832 eval-logloss:0.530736
## [217] train-logloss:0.530169 eval-logloss:0.530073
## [218] train-logloss:0.529502 eval-logloss:0.529405
## [219] train-logloss:0.528835 eval-logloss:0.528738
## [220] train-logloss:0.528138 eval-logloss:0.528042
## [221] train-logloss:0.527474 eval-logloss:0.527377
## [222] train-logloss:0.526779 eval-logloss:0.526683

```

```

## [223] train-logloss:0.526086 eval-logloss:0.525990
## [224] train-logloss:0.525425 eval-logloss:0.525328
## [225] train-logloss:0.524772 eval-logloss:0.524675
## [226] train-logloss:0.524082 eval-logloss:0.523985
## [227] train-logloss:0.523424 eval-logloss:0.523327
## [228] train-logloss:0.522989 eval-logloss:0.522891
## [229] train-logloss:0.522334 eval-logloss:0.522235
## [230] train-logloss:0.521679 eval-logloss:0.521580
## [231] train-logloss:0.521032 eval-logloss:0.520932
## [232] train-logloss:0.520385 eval-logloss:0.520285
## [233] train-logloss:0.519740 eval-logloss:0.519640
## [234] train-logloss:0.519059 eval-logloss:0.518959
## [235] train-logloss:0.518379 eval-logloss:0.518279
## [236] train-logloss:0.517737 eval-logloss:0.517637
## [237] train-logloss:0.517090 eval-logloss:0.516989
## [238] train-logloss:0.516444 eval-logloss:0.516343
## [239] train-logloss:0.515768 eval-logloss:0.515667
## [240] train-logloss:0.515124 eval-logloss:0.515023
## [241] train-logloss:0.514699 eval-logloss:0.514596
## [242] train-logloss:0.514057 eval-logloss:0.513954
## [243] train-logloss:0.513416 eval-logloss:0.513313
## [244] train-logloss:0.512993 eval-logloss:0.512888
## [245] train-logloss:0.512354 eval-logloss:0.512249
## [246] train-logloss:0.511685 eval-logloss:0.511580
## [247] train-logloss:0.511054 eval-logloss:0.510949
## [248] train-logloss:0.510418 eval-logloss:0.510313
## [249] train-logloss:0.509997 eval-logloss:0.509890
## [250] train-logloss:0.509617 eval-logloss:0.509509
## [251] train-logloss:0.509238 eval-logloss:0.509129
## [252] train-logloss:0.508605 eval-logloss:0.508496
## [253] train-logloss:0.507979 eval-logloss:0.507870
## [254] train-logloss:0.507354 eval-logloss:0.507245
## [255] train-logloss:0.506724 eval-logloss:0.506615
## [256] train-logloss:0.506096 eval-logloss:0.505986
## [257] train-logloss:0.505468 eval-logloss:0.505358
## [258] train-logloss:0.504841 eval-logloss:0.504731
## [259] train-logloss:0.504215 eval-logloss:0.504105
## [260] train-logloss:0.503560 eval-logloss:0.503449
## [261] train-logloss:0.502936 eval-logloss:0.502825
## [262] train-logloss:0.502282 eval-logloss:0.502172
## [263] train-logloss:0.501667 eval-logloss:0.501556
## [264] train-logloss:0.501047 eval-logloss:0.500936
## [265] train-logloss:0.500396 eval-logloss:0.500286
## [266] train-logloss:0.499747 eval-logloss:0.499636
## [267] train-logloss:0.499136 eval-logloss:0.499025
## [268] train-logloss:0.498802 eval-logloss:0.498690
## [269] train-logloss:0.498186 eval-logloss:0.498074
## [270] train-logloss:0.497571 eval-logloss:0.497459
## [271] train-logloss:0.496927 eval-logloss:0.496814
## [272] train-logloss:0.496314 eval-logloss:0.496201
## [273] train-logloss:0.495909 eval-logloss:0.495795
## [274] train-logloss:0.495304 eval-logloss:0.495190
## [275] train-logloss:0.494663 eval-logloss:0.494549
## [276] train-logloss:0.494054 eval-logloss:0.493940

```

```
## [277] train-logloss:0.493451 eval-logloss:0.493337
## [278] train-logloss:0.492844 eval-logloss:0.492730
## [279] train-logloss:0.492207 eval-logloss:0.492093
## [280] train-logloss:0.491602 eval-logloss:0.491488
## [281] train-logloss:0.491004 eval-logloss:0.490889
## [282] train-logloss:0.490370 eval-logloss:0.490256
## [283] train-logloss:0.490043 eval-logloss:0.489928
## [284] train-logloss:0.489447 eval-logloss:0.489332
## [285] train-logloss:0.488846 eval-logloss:0.488731
## [286] train-logloss:0.488216 eval-logloss:0.488101
## [287] train-logloss:0.487617 eval-logloss:0.487502
## [288] train-logloss:0.486989 eval-logloss:0.486874
## [289] train-logloss:0.486392 eval-logloss:0.486276
## [290] train-logloss:0.485796 eval-logloss:0.485680
## [291] train-logloss:0.485201 eval-logloss:0.485085
## [292] train-logloss:0.484613 eval-logloss:0.484497
## [293] train-logloss:0.484020 eval-logloss:0.483904
## [294] train-logloss:0.483434 eval-logloss:0.483317
## [295] train-logloss:0.482849 eval-logloss:0.482732
## [296] train-logloss:0.482265 eval-logloss:0.482148
## [297] train-logloss:0.481914 eval-logloss:0.481795
## [298] train-logloss:0.481331 eval-logloss:0.481212
## [299] train-logloss:0.480713 eval-logloss:0.480594
## [300] train-logloss:0.480126 eval-logloss:0.480007
## [301] train-logloss:0.479546 eval-logloss:0.479427
## [302] train-logloss:0.479228 eval-logloss:0.479108
## [303] train-logloss:0.478844 eval-logloss:0.478722
## [304] train-logloss:0.478260 eval-logloss:0.478138
## [305] train-logloss:0.477946 eval-logloss:0.477824
## [306] train-logloss:0.477630 eval-logloss:0.477506
## [307] train-logloss:0.477048 eval-logloss:0.476924
## [308] train-logloss:0.476467 eval-logloss:0.476343
## [309] train-logloss:0.475887 eval-logloss:0.475763
## [310] train-logloss:0.475308 eval-logloss:0.475184
## [311] train-logloss:0.474700 eval-logloss:0.474576
## [312] train-logloss:0.474123 eval-logloss:0.473999
## [313] train-logloss:0.473552 eval-logloss:0.473428
## [314] train-logloss:0.472977 eval-logloss:0.472853
## [315] train-logloss:0.472665 eval-logloss:0.472540
## [316] train-logloss:0.472061 eval-logloss:0.471936
## [317] train-logloss:0.471488 eval-logloss:0.471363
## [318] train-logloss:0.470922 eval-logloss:0.470796
## [319] train-logloss:0.470351 eval-logloss:0.470225
## [320] train-logloss:0.469787 eval-logloss:0.469661
## [321] train-logloss:0.469187 eval-logloss:0.469061
## [322] train-logloss:0.468619 eval-logloss:0.468493
## [323] train-logloss:0.468245 eval-logloss:0.468118
## [324] train-logloss:0.467684 eval-logloss:0.467557
## [325] train-logloss:0.467088 eval-logloss:0.466961
## [326] train-logloss:0.466492 eval-logloss:0.466366
## [327] train-logloss:0.465928 eval-logloss:0.465802
## [328] train-logloss:0.465335 eval-logloss:0.465208
## [329] train-logloss:0.464773 eval-logloss:0.464646
## [330] train-logloss:0.464403 eval-logloss:0.464275
```

```

## [331] train-logloss:0.463842 eval-logloss:0.463714
## [332] train-logloss:0.463252 eval-logloss:0.463124
## [333] train-logloss:0.462693 eval-logloss:0.462565
## [334] train-logloss:0.462135 eval-logloss:0.462007
## [335] train-logloss:0.461583 eval-logloss:0.461455
## [336] train-logloss:0.461033 eval-logloss:0.460904
## [337] train-logloss:0.460477 eval-logloss:0.460348
## [338] train-logloss:0.459893 eval-logloss:0.459764
## [339] train-logloss:0.459345 eval-logloss:0.459216
## [340] train-logloss:0.458762 eval-logloss:0.458633
## [341] train-logloss:0.458210 eval-logloss:0.458081
## [342] train-logloss:0.457629 eval-logloss:0.457500
## [343] train-logloss:0.457048 eval-logloss:0.456920
## [344] train-logloss:0.456689 eval-logloss:0.456559
## [345] train-logloss:0.456140 eval-logloss:0.456010
## [346] train-logloss:0.455592 eval-logloss:0.455462
## [347] train-logloss:0.455015 eval-logloss:0.454885
## [348] train-logloss:0.454439 eval-logloss:0.454309
## [349] train-logloss:0.453899 eval-logloss:0.453769
## [350] train-logloss:0.453360 eval-logloss:0.453230
## [351] train-logloss:0.452787 eval-logloss:0.452656
## [352] train-logloss:0.452244 eval-logloss:0.452113
## [353] train-logloss:0.451702 eval-logloss:0.451571
## [354] train-logloss:0.451409 eval-logloss:0.451278
## [355] train-logloss:0.450868 eval-logloss:0.450737
## [356] train-logloss:0.450334 eval-logloss:0.450202
## [357] train-logloss:0.449801 eval-logloss:0.449669
## [358] train-logloss:0.449263 eval-logloss:0.449131
## [359] train-logloss:0.448910 eval-logloss:0.448777
## [360] train-logloss:0.448379 eval-logloss:0.448246
## [361] train-logloss:0.447843 eval-logloss:0.447710
## [362] train-logloss:0.447308 eval-logloss:0.447175
## [363] train-logloss:0.446780 eval-logloss:0.446646
## [364] train-logloss:0.446252 eval-logloss:0.446118
## [365] train-logloss:0.445963 eval-logloss:0.445828
## [366] train-logloss:0.445401 eval-logloss:0.445266
## [367] train-logloss:0.444875 eval-logloss:0.444740
## [368] train-logloss:0.444345 eval-logloss:0.444210
## [369] train-logloss:0.443815 eval-logloss:0.443680
## [370] train-logloss:0.443292 eval-logloss:0.443156
## [371] train-logloss:0.442770 eval-logloss:0.442634
## [372] train-logloss:0.442243 eval-logloss:0.442107
## [373] train-logloss:0.441722 eval-logloss:0.441586
## [374] train-logloss:0.441197 eval-logloss:0.441060
## [375] train-logloss:0.440642 eval-logloss:0.440506
## [376] train-logloss:0.440124 eval-logloss:0.439987
## [377] train-logloss:0.439601 eval-logloss:0.439464
## [378] train-logloss:0.439085 eval-logloss:0.438947
## [379] train-logloss:0.438569 eval-logloss:0.438431
## [380] train-logloss:0.438018 eval-logloss:0.437881
## [381] train-logloss:0.437504 eval-logloss:0.437366
## [382] train-logloss:0.436955 eval-logloss:0.436818
## [383] train-logloss:0.436437 eval-logloss:0.436299
## [384] train-logloss:0.435920 eval-logloss:0.435782

```

```

## [385] train-logloss:0.435373 eval-logloss:0.435236
## [386] train-logloss:0.435035 eval-logloss:0.434897
## [387] train-logloss:0.434490 eval-logloss:0.434352
## [388] train-logloss:0.433981 eval-logloss:0.433843
## [389] train-logloss:0.433473 eval-logloss:0.433334
## [390] train-logloss:0.432966 eval-logloss:0.432827
## [391] train-logloss:0.432454 eval-logloss:0.432314
## [392] train-logloss:0.431948 eval-logloss:0.431808
## [393] train-logloss:0.431408 eval-logloss:0.431268
## [394] train-logloss:0.430898 eval-logloss:0.430758
## [395] train-logloss:0.430395 eval-logloss:0.430255
## [396] train-logloss:0.429887 eval-logloss:0.429747
## [397] train-logloss:0.429350 eval-logloss:0.429210
## [398] train-logloss:0.428843 eval-logloss:0.428703
## [399] train-logloss:0.428337 eval-logloss:0.428197
## [400] train-logloss:0.428068 eval-logloss:0.427926
## [401] train-logloss:0.427534 eval-logloss:0.427392
## [402] train-logloss:0.427035 eval-logloss:0.426894
## [403] train-logloss:0.426538 eval-logloss:0.426396
## [404] train-logloss:0.426036 eval-logloss:0.425893
## [405] train-logloss:0.425504 eval-logloss:0.425362
## [406] train-logloss:0.425004 eval-logloss:0.424862
## [407] train-logloss:0.424474 eval-logloss:0.424332
## [408] train-logloss:0.424147 eval-logloss:0.424004
## [409] train-logloss:0.423654 eval-logloss:0.423511
## [410] train-logloss:0.423126 eval-logloss:0.422984
## [411] train-logloss:0.422629 eval-logloss:0.422486
## [412] train-logloss:0.422306 eval-logloss:0.422162
## [413] train-logloss:0.421810 eval-logloss:0.421666
## [414] train-logloss:0.421315 eval-logloss:0.421170
## [415] train-logloss:0.421023 eval-logloss:0.420878
## [416] train-logloss:0.420535 eval-logloss:0.420389
## [417] train-logloss:0.420047 eval-logloss:0.419901
## [418] train-logloss:0.419555 eval-logloss:0.419408
## [419] train-logloss:0.419063 eval-logloss:0.418917
## [420] train-logloss:0.418542 eval-logloss:0.418396
## [421] train-logloss:0.418057 eval-logloss:0.417911
## [422] train-logloss:0.417568 eval-logloss:0.417421
## [423] train-logloss:0.417079 eval-logloss:0.416933
## [424] train-logloss:0.416592 eval-logloss:0.416445
## [425] train-logloss:0.416104 eval-logloss:0.415957
## [426] train-logloss:0.415786 eval-logloss:0.415638
## [427] train-logloss:0.415300 eval-logloss:0.415152
## [428] train-logloss:0.414820 eval-logloss:0.414672
## [429] train-logloss:0.414558 eval-logloss:0.414409
## [430] train-logloss:0.414298 eval-logloss:0.414149
## [431] train-logloss:0.413820 eval-logloss:0.413670
## [432] train-logloss:0.413337 eval-logloss:0.413187
## [433] train-logloss:0.412855 eval-logloss:0.412705
## [434] train-logloss:0.412373 eval-logloss:0.412223
## [435] train-logloss:0.411863 eval-logloss:0.411713
## [436] train-logloss:0.411353 eval-logloss:0.411203
## [437] train-logloss:0.411040 eval-logloss:0.410890
## [438] train-logloss:0.410566 eval-logloss:0.410416

```

```
## [439] train-logloss:0.410088 eval-logloss:0.409937
## [440] train-logloss:0.409611 eval-logloss:0.409460
## [441] train-logloss:0.409354 eval-logloss:0.409202
## [442] train-logloss:0.408877 eval-logloss:0.408725
## [443] train-logloss:0.408567 eval-logloss:0.408414
## [444] train-logloss:0.408092 eval-logloss:0.407939
## [445] train-logloss:0.407618 eval-logloss:0.407465
## [446] train-logloss:0.407144 eval-logloss:0.406991
## [447] train-logloss:0.406671 eval-logloss:0.406518
## [448] train-logloss:0.406169 eval-logloss:0.406016
## [449] train-logloss:0.405698 eval-logloss:0.405544
## [450] train-logloss:0.405232 eval-logloss:0.405079
## [451] train-logloss:0.404762 eval-logloss:0.404608
## [452] train-logloss:0.404293 eval-logloss:0.404139
## [453] train-logloss:0.403824 eval-logloss:0.403670
## [454] train-logloss:0.403356 eval-logloss:0.403202
## [455] train-logloss:0.402889 eval-logloss:0.402734
## [456] train-logloss:0.402422 eval-logloss:0.402268
## [457] train-logloss:0.401927 eval-logloss:0.401772
## [458] train-logloss:0.401467 eval-logloss:0.401312
## [459] train-logloss:0.400972 eval-logloss:0.400818
## [460] train-logloss:0.400479 eval-logloss:0.400325
## [461] train-logloss:0.400016 eval-logloss:0.399862
## [462] train-logloss:0.399559 eval-logloss:0.399404
## [463] train-logloss:0.399067 eval-logloss:0.398913
## [464] train-logloss:0.398606 eval-logloss:0.398452
## [465] train-logloss:0.398151 eval-logloss:0.397996
## [466] train-logloss:0.397692 eval-logloss:0.397537
## [467] train-logloss:0.397203 eval-logloss:0.397048
## [468] train-logloss:0.396715 eval-logloss:0.396561
## [469] train-logloss:0.396469 eval-logloss:0.396313
## [470] train-logloss:0.396011 eval-logloss:0.395856
## [471] train-logloss:0.395560 eval-logloss:0.395404
## [472] train-logloss:0.395075 eval-logloss:0.394919
## [473] train-logloss:0.394619 eval-logloss:0.394464
## [474] train-logloss:0.394382 eval-logloss:0.394225
## [475] train-logloss:0.393899 eval-logloss:0.393742
## [476] train-logloss:0.393655 eval-logloss:0.393497
## [477] train-logloss:0.393202 eval-logloss:0.393044
## [478] train-logloss:0.392754 eval-logloss:0.392596
## [479] train-logloss:0.392273 eval-logloss:0.392115
## [480] train-logloss:0.391827 eval-logloss:0.391669
## [481] train-logloss:0.391377 eval-logloss:0.391218
## [482] train-logloss:0.391084 eval-logloss:0.390926
## [483] train-logloss:0.390795 eval-logloss:0.390634
## [484] train-logloss:0.390316 eval-logloss:0.390156
## [485] train-logloss:0.389868 eval-logloss:0.389708
## [486] train-logloss:0.389426 eval-logloss:0.389265
## [487] train-logloss:0.388979 eval-logloss:0.388818
## [488] train-logloss:0.388503 eval-logloss:0.388342
## [489] train-logloss:0.388058 eval-logloss:0.387897
## [490] train-logloss:0.387583 eval-logloss:0.387423
## [491] train-logloss:0.387139 eval-logloss:0.386978
## [492] train-logloss:0.386700 eval-logloss:0.386539
```

```
## [493] train-logloss:0.386258 eval-logloss:0.386096
## [494] train-logloss:0.385815 eval-logloss:0.385654
## [495] train-logloss:0.385379 eval-logloss:0.385217
## [496] train-logloss:0.385150 eval-logloss:0.384987
## [497] train-logloss:0.384680 eval-logloss:0.384517
## [498] train-logloss:0.384210 eval-logloss:0.384048
## [499] train-logloss:0.383771 eval-logloss:0.383609
## [500] train-logloss:0.383303 eval-logloss:0.383141
## [501] train-logloss:0.382836 eval-logloss:0.382674
## [502] train-logloss:0.382369 eval-logloss:0.382208
## [503] train-logloss:0.382135 eval-logloss:0.381972
## [504] train-logloss:0.381698 eval-logloss:0.381536
## [505] train-logloss:0.381267 eval-logloss:0.381105
## [506] train-logloss:0.380837 eval-logloss:0.380674
## [507] train-logloss:0.380374 eval-logloss:0.380211
## [508] train-logloss:0.379940 eval-logloss:0.379777
## [509] train-logloss:0.379478 eval-logloss:0.379315
## [510] train-logloss:0.379045 eval-logloss:0.378882
## [511] train-logloss:0.378613 eval-logloss:0.378450
## [512] train-logloss:0.378182 eval-logloss:0.378019
## [513] train-logloss:0.377751 eval-logloss:0.377588
## [514] train-logloss:0.377321 eval-logloss:0.377158
## [515] train-logloss:0.376897 eval-logloss:0.376733
## [516] train-logloss:0.376473 eval-logloss:0.376309
## [517] train-logloss:0.376050 eval-logloss:0.375885
## [518] train-logloss:0.375593 eval-logloss:0.375429
## [519] train-logloss:0.375166 eval-logloss:0.375002
## [520] train-logloss:0.374711 eval-logloss:0.374547
## [521] train-logloss:0.374285 eval-logloss:0.374121
## [522] train-logloss:0.373860 eval-logloss:0.373696
## [523] train-logloss:0.373441 eval-logloss:0.373276
## [524] train-logloss:0.372988 eval-logloss:0.372823
## [525] train-logloss:0.372564 eval-logloss:0.372400
## [526] train-logloss:0.372142 eval-logloss:0.371977
## [527] train-logloss:0.371691 eval-logloss:0.371527
## [528] train-logloss:0.371270 eval-logloss:0.371105
## [529] train-logloss:0.370820 eval-logloss:0.370656
## [530] train-logloss:0.370405 eval-logloss:0.370240
## [531] train-logloss:0.369985 eval-logloss:0.369821
## [532] train-logloss:0.369571 eval-logloss:0.369406
## [533] train-logloss:0.369158 eval-logloss:0.368992
## [534] train-logloss:0.368740 eval-logloss:0.368575
## [535] train-logloss:0.368323 eval-logloss:0.368158
## [536] train-logloss:0.367907 eval-logloss:0.367741
## [537] train-logloss:0.367491 eval-logloss:0.367325
## [538] train-logloss:0.367047 eval-logloss:0.366881
## [539] train-logloss:0.366632 eval-logloss:0.366466
## [540] train-logloss:0.366394 eval-logloss:0.366228
## [541] train-logloss:0.365980 eval-logloss:0.365814
## [542] train-logloss:0.365567 eval-logloss:0.365400
## [543] train-logloss:0.365126 eval-logloss:0.364959
## [544] train-logloss:0.364719 eval-logloss:0.364552
## [545] train-logloss:0.364312 eval-logloss:0.364145
## [546] train-logloss:0.363906 eval-logloss:0.363739
```

```

## [547] train-logloss:0.363496 eval-logloss:0.363329
## [548] train-logloss:0.363091 eval-logloss:0.362923
## [549] train-logloss:0.362687 eval-logloss:0.362519
## [550] train-logloss:0.362283 eval-logloss:0.362115
## [551] train-logloss:0.361880 eval-logloss:0.361712
## [552] train-logloss:0.361444 eval-logloss:0.361276
## [553] train-logloss:0.361009 eval-logloss:0.360841
## [554] train-logloss:0.360794 eval-logloss:0.360625
## [555] train-logloss:0.360393 eval-logloss:0.360224
## [556] train-logloss:0.359993 eval-logloss:0.359823
## [557] train-logloss:0.359588 eval-logloss:0.359419
## [558] train-logloss:0.359184 eval-logloss:0.359015
## [559] train-logloss:0.358786 eval-logloss:0.358616
## [560] train-logloss:0.358388 eval-logloss:0.358217
## [561] train-logloss:0.357986 eval-logloss:0.357815
## [562] train-logloss:0.357584 eval-logloss:0.357413
## [563] train-logloss:0.357183 eval-logloss:0.357012
## [564] train-logloss:0.356753 eval-logloss:0.356583
## [565] train-logloss:0.356354 eval-logloss:0.356183
## [566] train-logloss:0.355954 eval-logloss:0.355783
## [567] train-logloss:0.355527 eval-logloss:0.355356
## [568] train-logloss:0.355100 eval-logloss:0.354929
## [569] train-logloss:0.354673 eval-logloss:0.354503
## [570] train-logloss:0.354276 eval-logloss:0.354106
## [571] train-logloss:0.353880 eval-logloss:0.353709
## [572] train-logloss:0.353484 eval-logloss:0.353313
## [573] train-logloss:0.353088 eval-logloss:0.352918
## [574] train-logloss:0.352859 eval-logloss:0.352687
## [575] train-logloss:0.352436 eval-logloss:0.352264
## [576] train-logloss:0.352013 eval-logloss:0.351842
## [577] train-logloss:0.351620 eval-logloss:0.351448
## [578] train-logloss:0.351227 eval-logloss:0.351055
## [579] train-logloss:0.350835 eval-logloss:0.350663
## [580] train-logloss:0.350448 eval-logloss:0.350276
## [581] train-logloss:0.350057 eval-logloss:0.349885
## [582] train-logloss:0.349637 eval-logloss:0.349466
## [583] train-logloss:0.349219 eval-logloss:0.349047
## [584] train-logloss:0.348801 eval-logloss:0.348629
## [585] train-logloss:0.348383 eval-logloss:0.348212
## [586] train-logloss:0.347995 eval-logloss:0.347824
## [587] train-logloss:0.347612 eval-logloss:0.347440
## [588] train-logloss:0.347229 eval-logloss:0.347057
## [589] train-logloss:0.346843 eval-logloss:0.346671
## [590] train-logloss:0.346637 eval-logloss:0.346465
## [591] train-logloss:0.346223 eval-logloss:0.346051
## [592] train-logloss:0.345838 eval-logloss:0.345665
## [593] train-logloss:0.345453 eval-logloss:0.345281
## [594] train-logloss:0.345069 eval-logloss:0.344896
## [595] train-logloss:0.344690 eval-logloss:0.344517
## [596] train-logloss:0.344311 eval-logloss:0.344138
## [597] train-logloss:0.343929 eval-logloss:0.343756
## [598] train-logloss:0.343547 eval-logloss:0.343374
## [599] train-logloss:0.343343 eval-logloss:0.343169
## [600] train-logloss:0.342933 eval-logloss:0.342760

```

```

## [601] train-logloss:0.342524 eval-logloss:0.342351
## [602] train-logloss:0.342115 eval-logloss:0.341942
## [603] train-logloss:0.341912 eval-logloss:0.341739
## [604] train-logloss:0.341668 eval-logloss:0.341493
## [605] train-logloss:0.341260 eval-logloss:0.341086
## [606] train-logloss:0.340853 eval-logloss:0.340679
## [607] train-logloss:0.340475 eval-logloss:0.340301
## [608] train-logloss:0.340070 eval-logloss:0.339896
## [609] train-logloss:0.339693 eval-logloss:0.339519
## [610] train-logloss:0.339288 eval-logloss:0.339115
## [611] train-logloss:0.338884 eval-logloss:0.338711
## [612] train-logloss:0.338513 eval-logloss:0.338340
## [613] train-logloss:0.338139 eval-logloss:0.337965
## [614] train-logloss:0.337765 eval-logloss:0.337591
## [615] train-logloss:0.337363 eval-logloss:0.337189
## [616] train-logloss:0.337167 eval-logloss:0.336993
## [617] train-logloss:0.336794 eval-logloss:0.336620
## [618] train-logloss:0.336554 eval-logloss:0.336379
## [619] train-logloss:0.336154 eval-logloss:0.335979
## [620] train-logloss:0.335754 eval-logloss:0.335580
## [621] train-logloss:0.335388 eval-logloss:0.335213
## [622] train-logloss:0.335193 eval-logloss:0.335018
## [623] train-logloss:0.334827 eval-logloss:0.334652
## [624] train-logloss:0.334458 eval-logloss:0.334282
## [625] train-logloss:0.334094 eval-logloss:0.333917
## [626] train-logloss:0.333729 eval-logloss:0.333553
## [627] train-logloss:0.333517 eval-logloss:0.333340
## [628] train-logloss:0.333121 eval-logloss:0.332944
## [629] train-logloss:0.332928 eval-logloss:0.332750
## [630] train-logloss:0.332716 eval-logloss:0.332538
## [631] train-logloss:0.332481 eval-logloss:0.332302
## [632] train-logloss:0.332087 eval-logloss:0.331908
## [633] train-logloss:0.331693 eval-logloss:0.331514
## [634] train-logloss:0.331332 eval-logloss:0.331153
## [635] train-logloss:0.330939 eval-logloss:0.330760
## [636] train-logloss:0.330705 eval-logloss:0.330525
## [637] train-logloss:0.330514 eval-logloss:0.330334
## [638] train-logloss:0.330155 eval-logloss:0.329975
## [639] train-logloss:0.329797 eval-logloss:0.329616
## [640] train-logloss:0.329438 eval-logloss:0.329258
## [641] train-logloss:0.329048 eval-logloss:0.328867
## [642] train-logloss:0.328691 eval-logloss:0.328510
## [643] train-logloss:0.328482 eval-logloss:0.328301
## [644] train-logloss:0.328093 eval-logloss:0.327912
## [645] train-logloss:0.327737 eval-logloss:0.327556
## [646] train-logloss:0.327378 eval-logloss:0.327196
## [647] train-logloss:0.327018 eval-logloss:0.326837
## [648] train-logloss:0.326631 eval-logloss:0.326450
## [649] train-logloss:0.326401 eval-logloss:0.326219
## [650] train-logloss:0.326048 eval-logloss:0.325866
## [651] train-logloss:0.325695 eval-logloss:0.325512
## [652] train-logloss:0.325310 eval-logloss:0.325127
## [653] train-logloss:0.324925 eval-logloss:0.324743
## [654] train-logloss:0.324569 eval-logloss:0.324387

```

```
## [655] train-logloss:0.324218 eval-logloss:0.324036
## [656] train-logloss:0.323867 eval-logloss:0.323685
## [657] train-logloss:0.323513 eval-logloss:0.323330
## [658] train-logloss:0.323163 eval-logloss:0.322980
## [659] train-logloss:0.322810 eval-logloss:0.322627
## [660] train-logloss:0.322584 eval-logloss:0.322400
## [661] train-logloss:0.322231 eval-logloss:0.322047
## [662] train-logloss:0.321851 eval-logloss:0.321667
## [663] train-logloss:0.321503 eval-logloss:0.321319
## [664] train-logloss:0.321124 eval-logloss:0.320940
## [665] train-logloss:0.320773 eval-logloss:0.320589
## [666] train-logloss:0.320423 eval-logloss:0.320239
## [667] train-logloss:0.320073 eval-logloss:0.319889
## [668] train-logloss:0.319724 eval-logloss:0.319540
## [669] train-logloss:0.319375 eval-logloss:0.319191
## [670] train-logloss:0.319027 eval-logloss:0.318843
## [671] train-logloss:0.318651 eval-logloss:0.318467
## [672] train-logloss:0.318276 eval-logloss:0.318092
## [673] train-logloss:0.317901 eval-logloss:0.317717
## [674] train-logloss:0.317554 eval-logloss:0.317370
## [675] train-logloss:0.317333 eval-logloss:0.317148
## [676] train-logloss:0.316991 eval-logloss:0.316807
## [677] train-logloss:0.316647 eval-logloss:0.316462
## [678] train-logloss:0.316302 eval-logloss:0.316117
## [679] train-logloss:0.316082 eval-logloss:0.315896
## [680] train-logloss:0.315710 eval-logloss:0.315524
## [681] train-logloss:0.315529 eval-logloss:0.315344
## [682] train-logloss:0.315186 eval-logloss:0.315001
## [683] train-logloss:0.315007 eval-logloss:0.314821
## [684] train-logloss:0.314668 eval-logloss:0.314483
## [685] train-logloss:0.314298 eval-logloss:0.314113
## [686] train-logloss:0.313929 eval-logloss:0.313743
## [687] train-logloss:0.313588 eval-logloss:0.313402
## [688] train-logloss:0.313219 eval-logloss:0.313034
## [689] train-logloss:0.312851 eval-logloss:0.312666
## [690] train-logloss:0.312512 eval-logloss:0.312326
## [691] train-logloss:0.312177 eval-logloss:0.311991
## [692] train-logloss:0.311961 eval-logloss:0.311775
## [693] train-logloss:0.311622 eval-logloss:0.311436
## [694] train-logloss:0.311285 eval-logloss:0.311098
## [695] train-logloss:0.310951 eval-logloss:0.310765
## [696] train-logloss:0.310619 eval-logloss:0.310432
## [697] train-logloss:0.310282 eval-logloss:0.310096
## [698] train-logloss:0.310069 eval-logloss:0.309881
## [699] train-logloss:0.309733 eval-logloss:0.309545
## [700] train-logloss:0.309402 eval-logloss:0.309214
## [701] train-logloss:0.309067 eval-logloss:0.308879
## [702] train-logloss:0.308737 eval-logloss:0.308549
## [703] train-logloss:0.308408 eval-logloss:0.308219
## [704] train-logloss:0.308074 eval-logloss:0.307886
## [705] train-logloss:0.307742 eval-logloss:0.307553
## [706] train-logloss:0.307551 eval-logloss:0.307361
## [707] train-logloss:0.307223 eval-logloss:0.307033
## [708] train-logloss:0.306863 eval-logloss:0.306673
```

```

## [709] train-logloss:0.306531 eval-logloss:0.306342
## [710] train-logloss:0.306205 eval-logloss:0.306015
## [711] train-logloss:0.305874 eval-logloss:0.305684
## [712] train-logloss:0.305664 eval-logloss:0.305473
## [713] train-logloss:0.305339 eval-logloss:0.305148
## [714] train-logloss:0.305009 eval-logloss:0.304818
## [715] train-logloss:0.304685 eval-logloss:0.304494
## [716] train-logloss:0.304515 eval-logloss:0.304323
## [717] train-logloss:0.304187 eval-logloss:0.303995
## [718] train-logloss:0.303831 eval-logloss:0.303639
## [719] train-logloss:0.303508 eval-logloss:0.303316
## [720] train-logloss:0.303185 eval-logloss:0.302993
## [721] train-logloss:0.302859 eval-logloss:0.302667
## [722] train-logloss:0.302537 eval-logloss:0.302345
## [723] train-logloss:0.302184 eval-logloss:0.301991
## [724] train-logloss:0.301859 eval-logloss:0.301666
## [725] train-logloss:0.301506 eval-logloss:0.301314
## [726] train-logloss:0.301182 eval-logloss:0.300990
## [727] train-logloss:0.300859 eval-logloss:0.300666
## [728] train-logloss:0.300690 eval-logloss:0.300497
## [729] train-logloss:0.300371 eval-logloss:0.300178
## [730] train-logloss:0.300053 eval-logloss:0.299859
## [731] train-logloss:0.299702 eval-logloss:0.299509
## [732] train-logloss:0.299381 eval-logloss:0.299187
## [733] train-logloss:0.299060 eval-logloss:0.298866
## [734] train-logloss:0.298891 eval-logloss:0.298697
## [735] train-logloss:0.298687 eval-logloss:0.298493
## [736] train-logloss:0.298339 eval-logloss:0.298145
## [737] train-logloss:0.298019 eval-logloss:0.297825
## [738] train-logloss:0.297817 eval-logloss:0.297622
## [739] train-logloss:0.297502 eval-logloss:0.297306
## [740] train-logloss:0.297183 eval-logloss:0.296988
## [741] train-logloss:0.296837 eval-logloss:0.296641
## [742] train-logloss:0.296655 eval-logloss:0.296459
## [743] train-logloss:0.296338 eval-logloss:0.296142
## [744] train-logloss:0.296136 eval-logloss:0.295940
## [745] train-logloss:0.295956 eval-logloss:0.295759
## [746] train-logloss:0.295643 eval-logloss:0.295446
## [747] train-logloss:0.295299 eval-logloss:0.295102
## [748] train-logloss:0.294983 eval-logloss:0.294786
## [749] train-logloss:0.294640 eval-logloss:0.294443
## [750] train-logloss:0.294329 eval-logloss:0.294132
## [751] train-logloss:0.294014 eval-logloss:0.293817
## [752] train-logloss:0.293672 eval-logloss:0.293475
## [753] train-logloss:0.293359 eval-logloss:0.293161
## [754] train-logloss:0.293045 eval-logloss:0.292848
## [755] train-logloss:0.292733 eval-logloss:0.292535
## [756] train-logloss:0.292424 eval-logloss:0.292227
## [757] train-logloss:0.292113 eval-logloss:0.291915
## [758] train-logloss:0.291805 eval-logloss:0.291607
## [759] train-logloss:0.291643 eval-logloss:0.291445
## [760] train-logloss:0.291333 eval-logloss:0.291134
## [761] train-logloss:0.291026 eval-logloss:0.290828
## [762] train-logloss:0.290720 eval-logloss:0.290521

```

```
## [763] train-logloss:0.290414 eval-logloss:0.290215
## [764] train-logloss:0.290219 eval-logloss:0.290019
## [765] train-logloss:0.289910 eval-logloss:0.289710
## [766] train-logloss:0.289573 eval-logloss:0.289374
## [767] train-logloss:0.289265 eval-logloss:0.289065
## [768] train-logloss:0.288961 eval-logloss:0.288762
## [769] train-logloss:0.288654 eval-logloss:0.288454
## [770] train-logloss:0.288347 eval-logloss:0.288147
## [771] train-logloss:0.288013 eval-logloss:0.287813
## [772] train-logloss:0.287679 eval-logloss:0.287479
## [773] train-logloss:0.287373 eval-logloss:0.287173
## [774] train-logloss:0.287072 eval-logloss:0.286872
## [775] train-logloss:0.286739 eval-logloss:0.286539
## [776] train-logloss:0.286435 eval-logloss:0.286235
## [777] train-logloss:0.286131 eval-logloss:0.285931
## [778] train-logloss:0.285827 eval-logloss:0.285627
## [779] train-logloss:0.285528 eval-logloss:0.285328
## [780] train-logloss:0.285229 eval-logloss:0.285029
## [781] train-logloss:0.284927 eval-logloss:0.284726
## [782] train-logloss:0.284629 eval-logloss:0.284428
## [783] train-logloss:0.284438 eval-logloss:0.284237
## [784] train-logloss:0.284141 eval-logloss:0.283939
## [785] train-logloss:0.283812 eval-logloss:0.283610
## [786] train-logloss:0.283483 eval-logloss:0.283282
## [787] train-logloss:0.283295 eval-logloss:0.283093
## [788] train-logloss:0.282995 eval-logloss:0.282793
## [789] train-logloss:0.282695 eval-logloss:0.282493
## [790] train-logloss:0.282397 eval-logloss:0.282194
## [791] train-logloss:0.282098 eval-logloss:0.281895
## [792] train-logloss:0.281800 eval-logloss:0.281597
## [793] train-logloss:0.281474 eval-logloss:0.281271
## [794] train-logloss:0.281180 eval-logloss:0.280978
## [795] train-logloss:0.281025 eval-logloss:0.280822
## [796] train-logloss:0.280729 eval-logloss:0.280525
## [797] train-logloss:0.280574 eval-logloss:0.280370
## [798] train-logloss:0.280420 eval-logloss:0.280215
## [799] train-logloss:0.280267 eval-logloss:0.280063
## [800] train-logloss:0.279944 eval-logloss:0.279739
## [801] train-logloss:0.279620 eval-logloss:0.279416
## [802] train-logloss:0.279297 eval-logloss:0.279093
## [803] train-logloss:0.279006 eval-logloss:0.278802
## [804] train-logloss:0.278684 eval-logloss:0.278480
## [805] train-logloss:0.278531 eval-logloss:0.278327
## [806] train-logloss:0.278210 eval-logloss:0.278006
## [807] train-logloss:0.277917 eval-logloss:0.277712
## [808] train-logloss:0.277628 eval-logloss:0.277423
## [809] train-logloss:0.277307 eval-logloss:0.277103
## [810] train-logloss:0.277019 eval-logloss:0.276815
## [811] train-logloss:0.276700 eval-logloss:0.276495
## [812] train-logloss:0.276516 eval-logloss:0.276311
## [813] train-logloss:0.276197 eval-logloss:0.275993
## [814] train-logloss:0.275910 eval-logloss:0.275706
## [815] train-logloss:0.275727 eval-logloss:0.275522
## [816] train-logloss:0.275437 eval-logloss:0.275232
```

```
## [817] train-logloss:0.275148 eval-logloss:0.274943
## [818] train-logloss:0.274859 eval-logloss:0.274653
## [819] train-logloss:0.274542 eval-logloss:0.274337
## [820] train-logloss:0.274257 eval-logloss:0.274052
## [821] train-logloss:0.273973 eval-logloss:0.273767
## [822] train-logloss:0.273685 eval-logloss:0.273480
## [823] train-logloss:0.273398 eval-logloss:0.273192
## [824] train-logloss:0.273115 eval-logloss:0.272909
## [825] train-logloss:0.272801 eval-logloss:0.272595
## [826] train-logloss:0.272518 eval-logloss:0.272312
## [827] train-logloss:0.272236 eval-logloss:0.272030
## [828] train-logloss:0.272077 eval-logloss:0.271871
## [829] train-logloss:0.271931 eval-logloss:0.271724
## [830] train-logloss:0.271650 eval-logloss:0.271443
## [831] train-logloss:0.271366 eval-logloss:0.271158
## [832] train-logloss:0.271054 eval-logloss:0.270846
## [833] train-logloss:0.270742 eval-logloss:0.270535
## [834] train-logloss:0.270430 eval-logloss:0.270224
## [835] train-logloss:0.270147 eval-logloss:0.269940
## [836] train-logloss:0.269837 eval-logloss:0.269630
## [837] train-logloss:0.269558 eval-logloss:0.269351
## [838] train-logloss:0.269248 eval-logloss:0.269042
## [839] train-logloss:0.269071 eval-logloss:0.268864
## [840] train-logloss:0.268927 eval-logloss:0.268719
## [841] train-logloss:0.268750 eval-logloss:0.268542
## [842] train-logloss:0.268473 eval-logloss:0.268265
## [843] train-logloss:0.268297 eval-logloss:0.268089
## [844] train-logloss:0.268020 eval-logloss:0.267812
## [845] train-logloss:0.267740 eval-logloss:0.267532
## [846] train-logloss:0.267433 eval-logloss:0.267225
## [847] train-logloss:0.267154 eval-logloss:0.266945
## [848] train-logloss:0.266847 eval-logloss:0.266639
## [849] train-logloss:0.266541 eval-logloss:0.266333
## [850] train-logloss:0.266263 eval-logloss:0.266055
## [851] train-logloss:0.265989 eval-logloss:0.265780
## [852] train-logloss:0.265684 eval-logloss:0.265475
## [853] train-logloss:0.265543 eval-logloss:0.265334
## [854] train-logloss:0.265270 eval-logloss:0.265061
## [855] train-logloss:0.264994 eval-logloss:0.264785
## [856] train-logloss:0.264690 eval-logloss:0.264481
## [857] train-logloss:0.264418 eval-logloss:0.264209
## [858] train-logloss:0.264142 eval-logloss:0.263933
## [859] train-logloss:0.263867 eval-logloss:0.263658
## [860] train-logloss:0.263597 eval-logloss:0.263387
## [861] train-logloss:0.263322 eval-logloss:0.263113
## [862] train-logloss:0.263049 eval-logloss:0.262839
## [863] train-logloss:0.262775 eval-logloss:0.262565
## [864] train-logloss:0.262506 eval-logloss:0.262296
## [865] train-logloss:0.262205 eval-logloss:0.261995
## [866] train-logloss:0.261936 eval-logloss:0.261726
## [867] train-logloss:0.261636 eval-logloss:0.261427
## [868] train-logloss:0.261368 eval-logloss:0.261159
## [869] train-logloss:0.261101 eval-logloss:0.260891
## [870] train-logloss:0.260830 eval-logloss:0.260620
```

```
## [871] train-logloss:0.260531 eval-logloss:0.260321
## [872] train-logloss:0.260261 eval-logloss:0.260051
## [873] train-logloss:0.259995 eval-logloss:0.259784
## [874] train-logloss:0.259725 eval-logloss:0.259515
## [875] train-logloss:0.259456 eval-logloss:0.259245
## [876] train-logloss:0.259187 eval-logloss:0.258976
## [877] train-logloss:0.258922 eval-logloss:0.258711
## [878] train-logloss:0.258654 eval-logloss:0.258443
## [879] train-logloss:0.258386 eval-logloss:0.258175
## [880] train-logloss:0.258218 eval-logloss:0.258007
## [881] train-logloss:0.257951 eval-logloss:0.257740
## [882] train-logloss:0.257656 eval-logloss:0.257445
## [883] train-logloss:0.257362 eval-logloss:0.257151
## [884] train-logloss:0.257096 eval-logloss:0.256885
## [885] train-logloss:0.256830 eval-logloss:0.256619
## [886] train-logloss:0.256565 eval-logloss:0.256353
## [887] train-logloss:0.256303 eval-logloss:0.256091
## [888] train-logloss:0.256038 eval-logloss:0.255827
## [889] train-logloss:0.255774 eval-logloss:0.255562
## [890] train-logloss:0.255482 eval-logloss:0.255270
## [891] train-logloss:0.255222 eval-logloss:0.255010
## [892] train-logloss:0.255057 eval-logloss:0.254845
## [893] train-logloss:0.254794 eval-logloss:0.254581
## [894] train-logloss:0.254534 eval-logloss:0.254322
## [895] train-logloss:0.254276 eval-logloss:0.254063
## [896] train-logloss:0.254013 eval-logloss:0.253800
## [897] train-logloss:0.253724 eval-logloss:0.253511
## [898] train-logloss:0.253560 eval-logloss:0.253347
## [899] train-logloss:0.253271 eval-logloss:0.253058
## [900] train-logloss:0.253140 eval-logloss:0.252927
## [901] train-logloss:0.252880 eval-logloss:0.252666
## [902] train-logloss:0.252591 eval-logloss:0.252378
## [903] train-logloss:0.252331 eval-logloss:0.252118
## [904] train-logloss:0.252072 eval-logloss:0.251858
## [905] train-logloss:0.251784 eval-logloss:0.251571
## [906] train-logloss:0.251529 eval-logloss:0.251315
## [907] train-logloss:0.251397 eval-logloss:0.251183
## [908] train-logloss:0.251111 eval-logloss:0.250897
## [909] train-logloss:0.250856 eval-logloss:0.250642
## [910] train-logloss:0.250602 eval-logloss:0.250388
## [911] train-logloss:0.250344 eval-logloss:0.250130
## [912] train-logloss:0.250060 eval-logloss:0.249846
## [913] train-logloss:0.249899 eval-logloss:0.249685
## [914] train-logloss:0.249642 eval-logloss:0.249428
## [915] train-logloss:0.249386 eval-logloss:0.249172
## [916] train-logloss:0.249134 eval-logloss:0.248919
## [917] train-logloss:0.249007 eval-logloss:0.248791
## [918] train-logloss:0.248755 eval-logloss:0.248539
## [919] train-logloss:0.248503 eval-logloss:0.248287
## [920] train-logloss:0.248221 eval-logloss:0.248005
## [921] train-logloss:0.247938 eval-logloss:0.247723
## [922] train-logloss:0.247657 eval-logloss:0.247442
## [923] train-logloss:0.247406 eval-logloss:0.247191
## [924] train-logloss:0.247156 eval-logloss:0.246941
```

```
## [925] train-logloss:0.246903 eval-logloss:0.246688
## [926] train-logloss:0.246650 eval-logloss:0.246435
## [927] train-logloss:0.246398 eval-logloss:0.246182
## [928] train-logloss:0.246149 eval-logloss:0.245933
## [929] train-logloss:0.245897 eval-logloss:0.245681
## [930] train-logloss:0.245649 eval-logloss:0.245433
## [931] train-logloss:0.245398 eval-logloss:0.245182
## [932] train-logloss:0.245147 eval-logloss:0.244931
## [933] train-logloss:0.244869 eval-logloss:0.244653
## [934] train-logloss:0.244619 eval-logloss:0.244402
## [935] train-logloss:0.244369 eval-logloss:0.244152
## [936] train-logloss:0.244241 eval-logloss:0.244025
## [937] train-logloss:0.244113 eval-logloss:0.243896
## [938] train-logloss:0.243864 eval-logloss:0.243647
## [939] train-logloss:0.243618 eval-logloss:0.243401
## [940] train-logloss:0.243492 eval-logloss:0.243274
## [941] train-logloss:0.243243 eval-logloss:0.243026
## [942] train-logloss:0.242967 eval-logloss:0.242750
## [943] train-logloss:0.242692 eval-logloss:0.242475
## [944] train-logloss:0.242444 eval-logloss:0.242227
## [945] train-logloss:0.242169 eval-logloss:0.241952
## [946] train-logloss:0.241926 eval-logloss:0.241709
## [947] train-logloss:0.241680 eval-logloss:0.241462
## [948] train-logloss:0.241526 eval-logloss:0.241309
## [949] train-logloss:0.241284 eval-logloss:0.241066
## [950] train-logloss:0.241038 eval-logloss:0.240820
## [951] train-logloss:0.240765 eval-logloss:0.240547
## [952] train-logloss:0.240613 eval-logloss:0.240394
## [953] train-logloss:0.240371 eval-logloss:0.240153
## [954] train-logloss:0.240220 eval-logloss:0.240001
## [955] train-logloss:0.240084 eval-logloss:0.239864
## [956] train-logloss:0.239932 eval-logloss:0.239712
## [957] train-logloss:0.239692 eval-logloss:0.239472
## [958] train-logloss:0.239420 eval-logloss:0.239200
## [959] train-logloss:0.239177 eval-logloss:0.238957
## [960] train-logloss:0.238938 eval-logloss:0.238717
## [961] train-logloss:0.238815 eval-logloss:0.238594
## [962] train-logloss:0.238573 eval-logloss:0.238352
## [963] train-logloss:0.238303 eval-logloss:0.238082
## [964] train-logloss:0.238033 eval-logloss:0.237813
## [965] train-logloss:0.237910 eval-logloss:0.237689
## [966] train-logloss:0.237668 eval-logloss:0.237447
## [967] train-logloss:0.237431 eval-logloss:0.237209
## [968] train-logloss:0.237190 eval-logloss:0.236968
## [969] train-logloss:0.237042 eval-logloss:0.236819
## [970] train-logloss:0.236805 eval-logloss:0.236582
## [971] train-logloss:0.236565 eval-logloss:0.236342
## [972] train-logloss:0.236297 eval-logloss:0.236075
## [973] train-logloss:0.236030 eval-logloss:0.235808
## [974] train-logloss:0.235909 eval-logloss:0.235687
## [975] train-logloss:0.235674 eval-logloss:0.235451
## [976] train-logloss:0.235435 eval-logloss:0.235212
## [977] train-logloss:0.235197 eval-logloss:0.234974
## [978] train-logloss:0.234931 eval-logloss:0.234708
```

```

## [979] train-logloss:0.234693 eval-logloss:0.234471
## [980] train-logloss:0.234428 eval-logloss:0.234206
## [981] train-logloss:0.234191 eval-logloss:0.233969
## [982] train-logloss:0.233927 eval-logloss:0.233704
## [983] train-logloss:0.233663 eval-logloss:0.233441
## [984] train-logloss:0.233427 eval-logloss:0.233204
## [985] train-logloss:0.233163 eval-logloss:0.232941
## [986] train-logloss:0.232931 eval-logloss:0.232709
## [987] train-logloss:0.232802 eval-logloss:0.232580
## [988] train-logloss:0.232567 eval-logloss:0.232344
## [989] train-logloss:0.232336 eval-logloss:0.232113
## [990] train-logloss:0.232219 eval-logloss:0.231995
## [991] train-logloss:0.231988 eval-logloss:0.231764
## [992] train-logloss:0.231726 eval-logloss:0.231503
## [993] train-logloss:0.231492 eval-logloss:0.231269
## [994] train-logloss:0.231259 eval-logloss:0.231035
## [995] train-logloss:0.230998 eval-logloss:0.230775
## [996] train-logloss:0.230765 eval-logloss:0.230542
## [997] train-logloss:0.230533 eval-logloss:0.230309
## [998] train-logloss:0.230304 eval-logloss:0.230080
## [999] train-logloss:0.230072 eval-logloss:0.229848
## [1000] train-logloss:0.229840 eval-logloss:0.229616
## [1] train-logloss:0.692177 eval-logloss:0.692178
## Multiple eval metrics are present. Will use eval_logloss for early stopping.
## Will train until eval_logloss hasn't improved in 10 rounds.
##
## [2] train-logloss:0.691202 eval-logloss:0.691202
## [3] train-logloss:0.690206 eval-logloss:0.690206
## [4] train-logloss:0.689369 eval-logloss:0.689370
## [5] train-logloss:0.688531 eval-logloss:0.688533
## [6] train-logloss:0.687563 eval-logloss:0.687564
## [7] train-logloss:0.686575 eval-logloss:0.686576
## [8] train-logloss:0.685589 eval-logloss:0.685590
## [9] train-logloss:0.684604 eval-logloss:0.684606
## [10] train-logloss:0.683622 eval-logloss:0.683623
## [11] train-logloss:0.682642 eval-logloss:0.682643
## [12] train-logloss:0.681663 eval-logloss:0.681665
## [13] train-logloss:0.680687 eval-logloss:0.680688
## [14] train-logloss:0.679733 eval-logloss:0.679734
## [15] train-logloss:0.678780 eval-logloss:0.678781
## [16] train-logloss:0.677809 eval-logloss:0.677810
## [17] train-logloss:0.676871 eval-logloss:0.676871
## [18] train-logloss:0.675904 eval-logloss:0.675904
## [19] train-logloss:0.674939 eval-logloss:0.674939
## [20] train-logloss:0.673991 eval-logloss:0.673991
## [21] train-logloss:0.673030 eval-logloss:0.673030
## [22] train-logloss:0.672071 eval-logloss:0.672070
## [23] train-logloss:0.671262 eval-logloss:0.671263
## [24] train-logloss:0.670322 eval-logloss:0.670322
## [25] train-logloss:0.669530 eval-logloss:0.669530
## [26] train-logloss:0.668578 eval-logloss:0.668578
## [27] train-logloss:0.667627 eval-logloss:0.667627
## [28] train-logloss:0.666678 eval-logloss:0.666678
## [29] train-logloss:0.665731 eval-logloss:0.665731

```

```
## [30] train-logloss:0.664785 eval-logloss:0.664786
## [31] train-logloss:0.663842 eval-logloss:0.663842
## [32] train-logloss:0.662901 eval-logloss:0.662901
## [33] train-logloss:0.661961 eval-logloss:0.661961
## [34] train-logloss:0.661171 eval-logloss:0.661172
## [35] train-logloss:0.660263 eval-logloss:0.660264
## [36] train-logloss:0.659328 eval-logloss:0.659330
## [37] train-logloss:0.658395 eval-logloss:0.658397
## [38] train-logloss:0.657876 eval-logloss:0.657879
## [39] train-logloss:0.657094 eval-logloss:0.657098
## [40] train-logloss:0.656181 eval-logloss:0.656185
## [41] train-logloss:0.655254 eval-logloss:0.655258
## [42] train-logloss:0.654330 eval-logloss:0.654333
## [43] train-logloss:0.653406 eval-logloss:0.653410
## [44] train-logloss:0.652485 eval-logloss:0.652488
## [45] train-logloss:0.651565 eval-logloss:0.651569
## [46] train-logloss:0.650647 eval-logloss:0.650651
## [47] train-logloss:0.649748 eval-logloss:0.649751
## [48] train-logloss:0.648849 eval-logloss:0.648851
## [49] train-logloss:0.648079 eval-logloss:0.648083
## [50] train-logloss:0.647168 eval-logloss:0.647172
## [51] train-logloss:0.646259 eval-logloss:0.646262
## [52] train-logloss:0.645366 eval-logloss:0.645369
## [53] train-logloss:0.644460 eval-logloss:0.644463
## [54] train-logloss:0.643698 eval-logloss:0.643702
## [55] train-logloss:0.643132 eval-logloss:0.643136
## [56] train-logloss:0.642230 eval-logloss:0.642234
## [57] train-logloss:0.641346 eval-logloss:0.641349
## [58] train-logloss:0.640447 eval-logloss:0.640451
## [59] train-logloss:0.639550 eval-logloss:0.639554
## [60] train-logloss:0.639050 eval-logloss:0.639053
## [61] train-logloss:0.638565 eval-logloss:0.638568
## [62] train-logloss:0.637671 eval-logloss:0.637674
## [63] train-logloss:0.636780 eval-logloss:0.636783
## [64] train-logloss:0.636287 eval-logloss:0.636291
## [65] train-logloss:0.635413 eval-logloss:0.635416
## [66] train-logloss:0.634861 eval-logloss:0.634864
## [67] train-logloss:0.634116 eval-logloss:0.634121
## [68] train-logloss:0.633232 eval-logloss:0.633236
## [69] train-logloss:0.632348 eval-logloss:0.632353
## [70] train-logloss:0.631467 eval-logloss:0.631472
## [71] train-logloss:0.630604 eval-logloss:0.630608
## [72] train-logloss:0.629747 eval-logloss:0.629750
## [73] train-logloss:0.628870 eval-logloss:0.628874
## [74] train-logloss:0.627995 eval-logloss:0.627999
## [75] train-logloss:0.627145 eval-logloss:0.627148
## [76] train-logloss:0.626273 eval-logloss:0.626277
## [77] train-logloss:0.625420 eval-logloss:0.625422
## [78] train-logloss:0.624551 eval-logloss:0.624554
## [79] train-logloss:0.623685 eval-logloss:0.623687
## [80] train-logloss:0.622840 eval-logloss:0.622843
## [81] train-logloss:0.621993 eval-logloss:0.621995
## [82] train-logloss:0.621145 eval-logloss:0.621146
## [83] train-logloss:0.620285 eval-logloss:0.620286
```

```

## [84] train-logloss:0.619440 eval-logloss:0.619441
## [85] train-logloss:0.618722 eval-logloss:0.618723
## [86] train-logloss:0.617866 eval-logloss:0.617867
## [87] train-logloss:0.617011 eval-logloss:0.617013
## [88] train-logloss:0.616159 eval-logloss:0.616160
## [89] train-logloss:0.615307 eval-logloss:0.615309
## [90] train-logloss:0.614458 eval-logloss:0.614459
## [91] train-logloss:0.613631 eval-logloss:0.613633
## [92] train-logloss:0.612785 eval-logloss:0.612786
## [93] train-logloss:0.611940 eval-logloss:0.611941
## [94] train-logloss:0.611097 eval-logloss:0.611098
## [95] train-logloss:0.610255 eval-logloss:0.610256
## [96] train-logloss:0.609414 eval-logloss:0.609416
## [97] train-logloss:0.608576 eval-logloss:0.608577
## [98] train-logloss:0.607738 eval-logloss:0.607740
## [99] train-logloss:0.607219 eval-logloss:0.607221
## [100] train-logloss:0.606385 eval-logloss:0.606386
## [101] train-logloss:0.605565 eval-logloss:0.605566
## [102] train-logloss:0.604760 eval-logloss:0.604761
## [103] train-logloss:0.603929 eval-logloss:0.603931
## [104] train-logloss:0.603101 eval-logloss:0.603102
## [105] train-logloss:0.602405 eval-logloss:0.602408
## [106] train-logloss:0.601579 eval-logloss:0.601582
## [107] train-logloss:0.600769 eval-logloss:0.600771
## [108] train-logloss:0.599946 eval-logloss:0.599948
## [109] train-logloss:0.599125 eval-logloss:0.599126
## [110] train-logloss:0.598328 eval-logloss:0.598330
## [111] train-logloss:0.597510 eval-logloss:0.597511
## [112] train-logloss:0.596706 eval-logloss:0.596708
## [113] train-logloss:0.595891 eval-logloss:0.595892
## [114] train-logloss:0.595091 eval-logloss:0.595091
## [115] train-logloss:0.594640 eval-logloss:0.594641
## [116] train-logloss:0.593828 eval-logloss:0.593829
## [117] train-logloss:0.593033 eval-logloss:0.593034
## [118] train-logloss:0.592225 eval-logloss:0.592225
## [119] train-logloss:0.591431 eval-logloss:0.591431
## [120] train-logloss:0.590625 eval-logloss:0.590625
## [121] train-logloss:0.589841 eval-logloss:0.589841
## [122] train-logloss:0.589038 eval-logloss:0.589037
## [123] train-logloss:0.588236 eval-logloss:0.588236
## [124] train-logloss:0.587450 eval-logloss:0.587449
## [125] train-logloss:0.586651 eval-logloss:0.586650
## [126] train-logloss:0.585854 eval-logloss:0.585853
## [127] train-logloss:0.585058 eval-logloss:0.585057
## [128] train-logloss:0.584263 eval-logloss:0.584262
## [129] train-logloss:0.583470 eval-logloss:0.583469
## [130] train-logloss:0.582678 eval-logloss:0.582678
## [131] train-logloss:0.581888 eval-logloss:0.581887
## [132] train-logloss:0.581228 eval-logloss:0.581228
## [133] train-logloss:0.580440 eval-logloss:0.580440
## [134] train-logloss:0.579654 eval-logloss:0.579654
## [135] train-logloss:0.578869 eval-logloss:0.578869
## [136] train-logloss:0.578085 eval-logloss:0.578085
## [137] train-logloss:0.577303 eval-logloss:0.577303

```

```

## [138] train-logloss:0.576523 eval-logloss:0.576523
## [139] train-logloss:0.575743 eval-logloss:0.575743
## [140] train-logloss:0.574965 eval-logloss:0.574966
## [141] train-logloss:0.574484 eval-logloss:0.574485
## [142] train-logloss:0.573723 eval-logloss:0.573724
## [143] train-logloss:0.572970 eval-logloss:0.572970
## [144] train-logloss:0.572197 eval-logloss:0.572197
## [145] train-logloss:0.571425 eval-logloss:0.571425
## [146] train-logloss:0.570668 eval-logloss:0.570668
## [147] train-logloss:0.569915 eval-logloss:0.569913
## [148] train-logloss:0.569147 eval-logloss:0.569146
## [149] train-logloss:0.568381 eval-logloss:0.568379
## [150] train-logloss:0.567616 eval-logloss:0.567615
## [151] train-logloss:0.566852 eval-logloss:0.566851
## [152] train-logloss:0.566103 eval-logloss:0.566102
## [153] train-logloss:0.565632 eval-logloss:0.565632
## [154] train-logloss:0.565223 eval-logloss:0.565222
## [155] train-logloss:0.564464 eval-logloss:0.564462
## [156] train-logloss:0.563706 eval-logloss:0.563704
## [157] train-logloss:0.562949 eval-logloss:0.562948
## [158] train-logloss:0.562483 eval-logloss:0.562482
## [159] train-logloss:0.561742 eval-logloss:0.561740
## [160] train-logloss:0.561110 eval-logloss:0.561109
## [161] train-logloss:0.560358 eval-logloss:0.560357
## [162] train-logloss:0.559729 eval-logloss:0.559730
## [163] train-logloss:0.558980 eval-logloss:0.558980
## [164] train-logloss:0.558231 eval-logloss:0.558232
## [165] train-logloss:0.557484 eval-logloss:0.557485
## [166] train-logloss:0.556760 eval-logloss:0.556761
## [167] train-logloss:0.556031 eval-logloss:0.556031
## [168] train-logloss:0.555287 eval-logloss:0.555287
## [169] train-logloss:0.554559 eval-logloss:0.554558
## [170] train-logloss:0.553818 eval-logloss:0.553818
## [171] train-logloss:0.553078 eval-logloss:0.553078
## [172] train-logloss:0.552355 eval-logloss:0.552354
## [173] train-logloss:0.551631 eval-logloss:0.551630
## [174] train-logloss:0.550896 eval-logloss:0.550894
## [175] train-logloss:0.550161 eval-logloss:0.550160
## [176] train-logloss:0.549428 eval-logloss:0.549427
## [177] train-logloss:0.548718 eval-logloss:0.548716
## [178] train-logloss:0.547987 eval-logloss:0.547986
## [179] train-logloss:0.547258 eval-logloss:0.547256
## [180] train-logloss:0.546530 eval-logloss:0.546528
## [181] train-logloss:0.545803 eval-logloss:0.545802
## [182] train-logloss:0.545195 eval-logloss:0.545195
## [183] train-logloss:0.544589 eval-logloss:0.544589
## [184] train-logloss:0.543865 eval-logloss:0.543866
## [185] train-logloss:0.543478 eval-logloss:0.543478
## [186] train-logloss:0.542756 eval-logloss:0.542757
## [187] train-logloss:0.542358 eval-logloss:0.542359
## [188] train-logloss:0.541638 eval-logloss:0.541640
## [189] train-logloss:0.540920 eval-logloss:0.540921
## [190] train-logloss:0.540203 eval-logloss:0.540204
## [191] train-logloss:0.539487 eval-logloss:0.539488

```

```

## [192] train-logloss:0.538772 eval-logloss:0.538774
## [193] train-logloss:0.538186 eval-logloss:0.538187
## [194] train-logloss:0.537473 eval-logloss:0.537475
## [195] train-logloss:0.536762 eval-logloss:0.536763
## [196] train-logloss:0.536052 eval-logloss:0.536053
## [197] train-logloss:0.535461 eval-logloss:0.535464
## [198] train-logloss:0.534753 eval-logloss:0.534756
## [199] train-logloss:0.534047 eval-logloss:0.534050
## [200] train-logloss:0.533360 eval-logloss:0.533363
## [201] train-logloss:0.532656 eval-logloss:0.532659
## [202] train-logloss:0.531953 eval-logloss:0.531955
## [203] train-logloss:0.531523 eval-logloss:0.531526
## [204] train-logloss:0.530946 eval-logloss:0.530948
## [205] train-logloss:0.530246 eval-logloss:0.530248
## [206] train-logloss:0.529568 eval-logloss:0.529571
## [207] train-logloss:0.528870 eval-logloss:0.528873
## [208] train-logloss:0.528192 eval-logloss:0.528194
## [209] train-logloss:0.527821 eval-logloss:0.527823
## [210] train-logloss:0.527139 eval-logloss:0.527140
## [211] train-logloss:0.526446 eval-logloss:0.526446
## [212] train-logloss:0.525753 eval-logloss:0.525754
## [213] train-logloss:0.525062 eval-logloss:0.525063
## [214] train-logloss:0.524372 eval-logloss:0.524373
## [215] train-logloss:0.523992 eval-logloss:0.523993
## [216] train-logloss:0.523304 eval-logloss:0.523305
## [217] train-logloss:0.522616 eval-logloss:0.522618
## [218] train-logloss:0.521930 eval-logloss:0.521932
## [219] train-logloss:0.521245 eval-logloss:0.521247
## [220] train-logloss:0.520884 eval-logloss:0.520885
## [221] train-logloss:0.520213 eval-logloss:0.520214
## [222] train-logloss:0.519531 eval-logloss:0.519532
## [223] train-logloss:0.518851 eval-logloss:0.518851
## [224] train-logloss:0.518171 eval-logloss:0.518172
## [225] train-logloss:0.517506 eval-logloss:0.517506
## [226] train-logloss:0.517133 eval-logloss:0.517135
## [227] train-logloss:0.516773 eval-logloss:0.516774
## [228] train-logloss:0.516110 eval-logloss:0.516111
## [229] train-logloss:0.515435 eval-logloss:0.515436
## [230] train-logloss:0.514761 eval-logloss:0.514762
## [231] train-logloss:0.514089 eval-logloss:0.514090
## [232] train-logloss:0.513417 eval-logloss:0.513418
## [233] train-logloss:0.512746 eval-logloss:0.512748
## [234] train-logloss:0.512077 eval-logloss:0.512078
## [235] train-logloss:0.511408 eval-logloss:0.511410
## [236] train-logloss:0.510741 eval-logloss:0.510743
## [237] train-logloss:0.510075 eval-logloss:0.510077
## [238] train-logloss:0.509410 eval-logloss:0.509412
## [239] train-logloss:0.508765 eval-logloss:0.508766
## [240] train-logloss:0.508102 eval-logloss:0.508103
## [241] train-logloss:0.507463 eval-logloss:0.507465
## [242] train-logloss:0.506912 eval-logloss:0.506915
## [243] train-logloss:0.506252 eval-logloss:0.506255
## [244] train-logloss:0.505593 eval-logloss:0.505597
## [245] train-logloss:0.504936 eval-logloss:0.504939

```

```
## [246] train-logloss:0.504279 eval-logloss:0.504283
## [247] train-logloss:0.503624 eval-logloss:0.503627
## [248] train-logloss:0.502970 eval-logloss:0.502973
## [249] train-logloss:0.502579 eval-logloss:0.502584
## [250] train-logloss:0.501927 eval-logloss:0.501931
## [251] train-logloss:0.501275 eval-logloss:0.501280
## [252] train-logloss:0.500625 eval-logloss:0.500629
## [253] train-logloss:0.499976 eval-logloss:0.499980
## [254] train-logloss:0.499327 eval-logloss:0.499332
## [255] train-logloss:0.498693 eval-logloss:0.498697
## [256] train-logloss:0.498047 eval-logloss:0.498051
## [257] train-logloss:0.497415 eval-logloss:0.497419
## [258] train-logloss:0.496771 eval-logloss:0.496775
## [259] train-logloss:0.496128 eval-logloss:0.496132
## [260] train-logloss:0.495486 eval-logloss:0.495490
## [261] train-logloss:0.494845 eval-logloss:0.494849
## [262] train-logloss:0.494206 eval-logloss:0.494209
## [263] train-logloss:0.493678 eval-logloss:0.493682
## [264] train-logloss:0.493040 eval-logloss:0.493044
## [265] train-logloss:0.492403 eval-logloss:0.492408
## [266] train-logloss:0.491767 eval-logloss:0.491772
## [267] train-logloss:0.491245 eval-logloss:0.491250
## [268] train-logloss:0.490611 eval-logloss:0.490616
## [269] train-logloss:0.489978 eval-logloss:0.489983
## [270] train-logloss:0.489358 eval-logloss:0.489362
## [271] train-logloss:0.488727 eval-logloss:0.488731
## [272] train-logloss:0.488114 eval-logloss:0.488118
## [273] train-logloss:0.487485 eval-logloss:0.487489
## [274] train-logloss:0.486874 eval-logloss:0.486878
## [275] train-logloss:0.486353 eval-logloss:0.486358
## [276] train-logloss:0.485745 eval-logloss:0.485751
## [277] train-logloss:0.485120 eval-logloss:0.485126
## [278] train-logloss:0.484496 eval-logloss:0.484502
## [279] train-logloss:0.483873 eval-logloss:0.483879
## [280] train-logloss:0.483251 eval-logloss:0.483257
## [281] train-logloss:0.482630 eval-logloss:0.482636
## [282] train-logloss:0.482010 eval-logloss:0.482016
## [283] train-logloss:0.481403 eval-logloss:0.481408
## [284] train-logloss:0.480785 eval-logloss:0.480791
## [285] train-logloss:0.480168 eval-logloss:0.480174
## [286] train-logloss:0.479841 eval-logloss:0.479846
## [287] train-logloss:0.479225 eval-logloss:0.479230
## [288] train-logloss:0.478611 eval-logloss:0.478616
## [289] train-logloss:0.478020 eval-logloss:0.478025
## [290] train-logloss:0.477408 eval-logloss:0.477413
## [291] train-logloss:0.476796 eval-logloss:0.476801
## [292] train-logloss:0.476186 eval-logloss:0.476191
## [293] train-logloss:0.475576 eval-logloss:0.475581
## [294] train-logloss:0.474967 eval-logloss:0.474973
## [295] train-logloss:0.474360 eval-logloss:0.474365
## [296] train-logloss:0.473766 eval-logloss:0.473771
## [297] train-logloss:0.473160 eval-logloss:0.473165
## [298] train-logloss:0.472829 eval-logloss:0.472835
## [299] train-logloss:0.472238 eval-logloss:0.472243
```

```

## [300] train-logloss:0.471635 eval-logloss:0.471640
## [301] train-logloss:0.471032 eval-logloss:0.471038
## [302] train-logloss:0.470444 eval-logloss:0.470448
## [303] train-logloss:0.469861 eval-logloss:0.469866
## [304] train-logloss:0.469273 eval-logloss:0.469277
## [305] train-logloss:0.468675 eval-logloss:0.468679
## [306] train-logloss:0.468077 eval-logloss:0.468081
## [307] train-logloss:0.467481 eval-logloss:0.467485
## [308] train-logloss:0.466904 eval-logloss:0.466908
## [309] train-logloss:0.466327 eval-logloss:0.466331
## [310] train-logloss:0.465744 eval-logloss:0.465748
## [311] train-logloss:0.465151 eval-logloss:0.465155
## [312] train-logloss:0.464571 eval-logloss:0.464574
## [313] train-logloss:0.463980 eval-logloss:0.463983
## [314] train-logloss:0.463390 eval-logloss:0.463393
## [315] train-logloss:0.462800 eval-logloss:0.462804
## [316] train-logloss:0.462212 eval-logloss:0.462216
## [317] train-logloss:0.461625 eval-logloss:0.461629
## [318] train-logloss:0.461039 eval-logloss:0.461042
## [319] train-logloss:0.460453 eval-logloss:0.460457
## [320] train-logloss:0.460144 eval-logloss:0.460147
## [321] train-logloss:0.459560 eval-logloss:0.459563
## [322] train-logloss:0.458977 eval-logloss:0.458980
## [323] train-logloss:0.458406 eval-logloss:0.458409
## [324] train-logloss:0.457825 eval-logloss:0.457828
## [325] train-logloss:0.457244 eval-logloss:0.457247
## [326] train-logloss:0.456682 eval-logloss:0.456685
## [327] train-logloss:0.456103 eval-logloss:0.456106
## [328] train-logloss:0.455526 eval-logloss:0.455529
## [329] train-logloss:0.454949 eval-logloss:0.454952
## [330] train-logloss:0.454389 eval-logloss:0.454392
## [331] train-logloss:0.453814 eval-logloss:0.453817
## [332] train-logloss:0.453240 eval-logloss:0.453244
## [333] train-logloss:0.452678 eval-logloss:0.452681
## [334] train-logloss:0.452376 eval-logloss:0.452378
## [335] train-logloss:0.451804 eval-logloss:0.451807
## [336] train-logloss:0.451252 eval-logloss:0.451254
## [337] train-logloss:0.450682 eval-logloss:0.450684
## [338] train-logloss:0.450113 eval-logloss:0.450115
## [339] train-logloss:0.449813 eval-logloss:0.449814
## [340] train-logloss:0.449245 eval-logloss:0.449247
## [341] train-logloss:0.448690 eval-logloss:0.448692
## [342] train-logloss:0.448124 eval-logloss:0.448126
## [343] train-logloss:0.447570 eval-logloss:0.447571
## [344] train-logloss:0.447006 eval-logloss:0.447007
## [345] train-logloss:0.446443 eval-logloss:0.446444
## [346] train-logloss:0.445880 eval-logloss:0.445881
## [347] train-logloss:0.445319 eval-logloss:0.445320
## [348] train-logloss:0.444854 eval-logloss:0.444856
## [349] train-logloss:0.444294 eval-logloss:0.444296
## [350] train-logloss:0.443734 eval-logloss:0.443737
## [351] train-logloss:0.443176 eval-logloss:0.443179
## [352] train-logloss:0.442619 eval-logloss:0.442621
## [353] train-logloss:0.442157 eval-logloss:0.442160

```

```

## [354] train-logloss:0.441612 eval-logloss:0.441615
## [355] train-logloss:0.441057 eval-logloss:0.441060
## [356] train-logloss:0.440766 eval-logloss:0.440769
## [357] train-logloss:0.440212 eval-logloss:0.440215
## [358] train-logloss:0.439659 eval-logloss:0.439663
## [359] train-logloss:0.439107 eval-logloss:0.439111
## [360] train-logloss:0.438568 eval-logloss:0.438571
## [361] train-logloss:0.438113 eval-logloss:0.438117
## [362] train-logloss:0.437575 eval-logloss:0.437579
## [363] train-logloss:0.437037 eval-logloss:0.437041
## [364] train-logloss:0.436490 eval-logloss:0.436493
## [365] train-logloss:0.435943 eval-logloss:0.435946
## [366] train-logloss:0.435396 eval-logloss:0.435400
## [367] train-logloss:0.434851 eval-logloss:0.434855
## [368] train-logloss:0.434555 eval-logloss:0.434559
## [369] train-logloss:0.434011 eval-logloss:0.434015
## [370] train-logloss:0.433486 eval-logloss:0.433490
## [371] train-logloss:0.432943 eval-logloss:0.432947
## [372] train-logloss:0.432402 eval-logloss:0.432406
## [373] train-logloss:0.431861 eval-logloss:0.431865
## [374] train-logloss:0.431321 eval-logloss:0.431326
## [375] train-logloss:0.431037 eval-logloss:0.431041
## [376] train-logloss:0.430498 eval-logloss:0.430502
## [377] train-logloss:0.429961 eval-logloss:0.429965
## [378] train-logloss:0.429439 eval-logloss:0.429443
## [379] train-logloss:0.428914 eval-logloss:0.428918
## [380] train-logloss:0.428379 eval-logloss:0.428383
## [381] train-logloss:0.427845 eval-logloss:0.427848
## [382] train-logloss:0.427323 eval-logloss:0.427326
## [383] train-logloss:0.426806 eval-logloss:0.426809
## [384] train-logloss:0.426526 eval-logloss:0.426528
## [385] train-logloss:0.426005 eval-logloss:0.426007
## [386] train-logloss:0.425493 eval-logloss:0.425495
## [387] train-logloss:0.424963 eval-logloss:0.424965
## [388] train-logloss:0.424445 eval-logloss:0.424446
## [389] train-logloss:0.423916 eval-logloss:0.423918
## [390] train-logloss:0.423388 eval-logloss:0.423390
## [391] train-logloss:0.422872 eval-logloss:0.422873
## [392] train-logloss:0.422346 eval-logloss:0.422347
## [393] train-logloss:0.421831 eval-logloss:0.421832
## [394] train-logloss:0.421307 eval-logloss:0.421308
## [395] train-logloss:0.420783 eval-logloss:0.420784
## [396] train-logloss:0.420271 eval-logloss:0.420271
## [397] train-logloss:0.419765 eval-logloss:0.419765
## [398] train-logloss:0.419259 eval-logloss:0.419259
## [399] train-logloss:0.418748 eval-logloss:0.418748
## [400] train-logloss:0.418240 eval-logloss:0.418240
## [401] train-logloss:0.417721 eval-logloss:0.417721
## [402] train-logloss:0.417289 eval-logloss:0.417291
## [403] train-logloss:0.417011 eval-logloss:0.417013
## [404] train-logloss:0.416510 eval-logloss:0.416511
## [405] train-logloss:0.416010 eval-logloss:0.416011
## [406] train-logloss:0.415494 eval-logloss:0.415496
## [407] train-logloss:0.415216 eval-logloss:0.415218

```

```

## [408] train-logloss:0.414949 eval-logloss:0.414952
## [409] train-logloss:0.414435 eval-logloss:0.414438
## [410] train-logloss:0.413922 eval-logloss:0.413925
## [411] train-logloss:0.413421 eval-logloss:0.413423
## [412] train-logloss:0.412920 eval-logloss:0.412922
## [413] train-logloss:0.412652 eval-logloss:0.412654
## [414] train-logloss:0.412142 eval-logloss:0.412143
## [415] train-logloss:0.411644 eval-logloss:0.411645
## [416] train-logloss:0.411135 eval-logloss:0.411136
## [417] train-logloss:0.410627 eval-logloss:0.410627
## [418] train-logloss:0.410119 eval-logloss:0.410120
## [419] train-logloss:0.409848 eval-logloss:0.409850
## [420] train-logloss:0.409356 eval-logloss:0.409358
## [421] train-logloss:0.408851 eval-logloss:0.408852
## [422] train-logloss:0.408356 eval-logloss:0.408357
## [423] train-logloss:0.407868 eval-logloss:0.407869
## [424] train-logloss:0.407364 eval-logloss:0.407365
## [425] train-logloss:0.406862 eval-logloss:0.406863
## [426] train-logloss:0.406360 eval-logloss:0.406361
## [427] train-logloss:0.406101 eval-logloss:0.406102
## [428] train-logloss:0.405600 eval-logloss:0.405602
## [429] train-logloss:0.405100 eval-logloss:0.405102
## [430] train-logloss:0.404611 eval-logloss:0.404612
## [431] train-logloss:0.404113 eval-logloss:0.404114
## [432] train-logloss:0.403627 eval-logloss:0.403627
## [433] train-logloss:0.403370 eval-logloss:0.403370
## [434] train-logloss:0.402873 eval-logloss:0.402873
## [435] train-logloss:0.402377 eval-logloss:0.402378
## [436] train-logloss:0.401882 eval-logloss:0.401882
## [437] train-logloss:0.401387 eval-logloss:0.401388
## [438] train-logloss:0.400894 eval-logloss:0.400894
## [439] train-logloss:0.400401 eval-logloss:0.400402
## [440] train-logloss:0.399926 eval-logloss:0.399927
## [441] train-logloss:0.399435 eval-logloss:0.399435
## [442] train-logloss:0.398954 eval-logloss:0.398954
## [443] train-logloss:0.398464 eval-logloss:0.398464
## [444] train-logloss:0.397975 eval-logloss:0.397975
## [445] train-logloss:0.397486 eval-logloss:0.397486
## [446] train-logloss:0.397008 eval-logloss:0.397008
## [447] train-logloss:0.396536 eval-logloss:0.396536
## [448] train-logloss:0.396050 eval-logloss:0.396050
## [449] train-logloss:0.395564 eval-logloss:0.395564
## [450] train-logloss:0.395161 eval-logloss:0.395163
## [451] train-logloss:0.394676 eval-logloss:0.394678
## [452] train-logloss:0.394208 eval-logloss:0.394211
## [453] train-logloss:0.393725 eval-logloss:0.393728
## [454] train-logloss:0.393243 eval-logloss:0.393245
## [455] train-logloss:0.392762 eval-logloss:0.392764
## [456] train-logloss:0.392281 eval-logloss:0.392283
## [457] train-logloss:0.391801 eval-logloss:0.391803
## [458] train-logloss:0.391321 eval-logloss:0.391324
## [459] train-logloss:0.390842 eval-logloss:0.390845
## [460] train-logloss:0.390364 eval-logloss:0.390367
## [461] train-logloss:0.389887 eval-logloss:0.389890

```

```
## [462] train-logloss:0.389631 eval-logloss:0.389634
## [463] train-logloss:0.389155 eval-logloss:0.389158
## [464] train-logloss:0.388679 eval-logloss:0.388682
## [465] train-logloss:0.388204 eval-logloss:0.388208
## [466] train-logloss:0.387740 eval-logloss:0.387743
## [467] train-logloss:0.387278 eval-logloss:0.387280
## [468] train-logloss:0.386885 eval-logloss:0.386890
## [469] train-logloss:0.386413 eval-logloss:0.386417
## [470] train-logloss:0.386021 eval-logloss:0.386027
## [471] train-logloss:0.385561 eval-logloss:0.385567
## [472] train-logloss:0.385091 eval-logloss:0.385097
## [473] train-logloss:0.384632 eval-logloss:0.384638
## [474] train-logloss:0.384164 eval-logloss:0.384169
## [475] train-logloss:0.383709 eval-logloss:0.383715
## [476] train-logloss:0.383242 eval-logloss:0.383247
## [477] train-logloss:0.382775 eval-logloss:0.382780
## [478] train-logloss:0.382388 eval-logloss:0.382395
## [479] train-logloss:0.381922 eval-logloss:0.381930
## [480] train-logloss:0.381457 eval-logloss:0.381465
## [481] train-logloss:0.380993 eval-logloss:0.381001
## [482] train-logloss:0.380530 eval-logloss:0.380537
## [483] train-logloss:0.380067 eval-logloss:0.380074
## [484] train-logloss:0.379684 eval-logloss:0.379693
## [485] train-logloss:0.379222 eval-logloss:0.379232
## [486] train-logloss:0.378761 eval-logloss:0.378771
## [487] train-logloss:0.378301 eval-logloss:0.378310
## [488] train-logloss:0.378023 eval-logloss:0.378033
## [489] train-logloss:0.377564 eval-logloss:0.377574
## [490] train-logloss:0.377106 eval-logloss:0.377116
## [491] train-logloss:0.376648 eval-logloss:0.376658
## [492] train-logloss:0.376191 eval-logloss:0.376201
## [493] train-logloss:0.375734 eval-logloss:0.375744
## [494] train-logloss:0.375278 eval-logloss:0.375288
## [495] train-logloss:0.374834 eval-logloss:0.374843
## [496] train-logloss:0.374379 eval-logloss:0.374389
## [497] train-logloss:0.373942 eval-logloss:0.373952
## [498] train-logloss:0.373489 eval-logloss:0.373499
## [499] train-logloss:0.373117 eval-logloss:0.373128
## [500] train-logloss:0.372674 eval-logloss:0.372685
## [501] train-logloss:0.372223 eval-logloss:0.372234
## [502] train-logloss:0.371772 eval-logloss:0.371783
## [503] train-logloss:0.371339 eval-logloss:0.371350
## [504] train-logloss:0.370899 eval-logloss:0.370909
## [505] train-logloss:0.370450 eval-logloss:0.370461
## [506] train-logloss:0.370002 eval-logloss:0.370012
## [507] train-logloss:0.369630 eval-logloss:0.369643
## [508] train-logloss:0.369398 eval-logloss:0.369411
## [509] train-logloss:0.368961 eval-logloss:0.368973
## [510] train-logloss:0.368515 eval-logloss:0.368527
## [511] train-logloss:0.368152 eval-logloss:0.368164
## [512] train-logloss:0.367913 eval-logloss:0.367926
## [513] train-logloss:0.367485 eval-logloss:0.367498
## [514] train-logloss:0.367041 eval-logloss:0.367054
## [515] train-logloss:0.3666598 eval-logloss:0.366611
```

```
## [516] train-logloss:0.366155 eval-logloss:0.366168
## [517] train-logloss:0.365723 eval-logloss:0.365735
## [518] train-logloss:0.365281 eval-logloss:0.365294
## [519] train-logloss:0.364850 eval-logloss:0.364863
## [520] train-logloss:0.364410 eval-logloss:0.364422
## [521] train-logloss:0.363971 eval-logloss:0.363983
## [522] train-logloss:0.363608 eval-logloss:0.363622
## [523] train-logloss:0.363381 eval-logloss:0.363395
## [524] train-logloss:0.363019 eval-logloss:0.363035
## [525] train-logloss:0.362581 eval-logloss:0.362597
## [526] train-logloss:0.362348 eval-logloss:0.362365
## [527] train-logloss:0.361911 eval-logloss:0.361928
## [528] train-logloss:0.361475 eval-logloss:0.361492
## [529] train-logloss:0.361040 eval-logloss:0.361057
## [530] train-logloss:0.360605 eval-logloss:0.360622
## [531] train-logloss:0.360182 eval-logloss:0.360198
## [532] train-logloss:0.359825 eval-logloss:0.359843
## [533] train-logloss:0.359594 eval-logloss:0.359612
## [534] train-logloss:0.359175 eval-logloss:0.359193
## [535] train-logloss:0.358743 eval-logloss:0.358761
## [536] train-logloss:0.358312 eval-logloss:0.358330
## [537] train-logloss:0.357881 eval-logloss:0.357899
## [538] train-logloss:0.357451 eval-logloss:0.357469
## [539] train-logloss:0.357021 eval-logloss:0.357039
## [540] train-logloss:0.356607 eval-logloss:0.356626
## [541] train-logloss:0.356260 eval-logloss:0.356279
## [542] train-logloss:0.355832 eval-logloss:0.355851
## [543] train-logloss:0.355405 eval-logloss:0.355424
## [544] train-logloss:0.354989 eval-logloss:0.355007
## [545] train-logloss:0.354563 eval-logloss:0.354581
## [546] train-logloss:0.354147 eval-logloss:0.354165
## [547] train-logloss:0.353722 eval-logloss:0.353740
## [548] train-logloss:0.353298 eval-logloss:0.353316
## [549] train-logloss:0.352874 eval-logloss:0.352892
## [550] train-logloss:0.352451 eval-logloss:0.352469
## [551] train-logloss:0.352045 eval-logloss:0.352063
## [552] train-logloss:0.351623 eval-logloss:0.351641
## [553] train-logloss:0.351202 eval-logloss:0.351220
## [554] train-logloss:0.350792 eval-logloss:0.350809
## [555] train-logloss:0.350372 eval-logloss:0.350389
## [556] train-logloss:0.349952 eval-logloss:0.349970
## [557] train-logloss:0.349533 eval-logloss:0.349551
## [558] train-logloss:0.349115 eval-logloss:0.349133
## [559] train-logloss:0.348697 eval-logloss:0.348715
## [560] train-logloss:0.348280 eval-logloss:0.348298
## [561] train-logloss:0.347864 eval-logloss:0.347882
## [562] train-logloss:0.347448 eval-logloss:0.347466
## [563] train-logloss:0.347033 eval-logloss:0.347051
## [564] train-logloss:0.346628 eval-logloss:0.346646
## [565] train-logloss:0.346228 eval-logloss:0.346245
## [566] train-logloss:0.345814 eval-logloss:0.345832
## [567] train-logloss:0.345410 eval-logloss:0.345427
## [568] train-logloss:0.345007 eval-logloss:0.345024
## [569] train-logloss:0.344788 eval-logloss:0.344805
```

```

## [570] train-logloss:0.344376 eval-logloss:0.344393
## [571] train-logloss:0.343965 eval-logloss:0.343982
## [572] train-logloss:0.343555 eval-logloss:0.343572
## [573] train-logloss:0.343145 eval-logloss:0.343162
## [574] train-logloss:0.342736 eval-logloss:0.342753
## [575] train-logloss:0.342327 eval-logloss:0.342344
## [576] train-logloss:0.341919 eval-logloss:0.341936
## [577] train-logloss:0.341512 eval-logloss:0.341529
## [578] train-logloss:0.341105 eval-logloss:0.341122
## [579] train-logloss:0.340698 eval-logloss:0.340716
## [580] train-logloss:0.340293 eval-logloss:0.340310
## [581] train-logloss:0.339887 eval-logloss:0.339905
## [582] train-logloss:0.339496 eval-logloss:0.339513
## [583] train-logloss:0.339092 eval-logloss:0.339109
## [584] train-logloss:0.338699 eval-logloss:0.338715
## [585] train-logloss:0.338296 eval-logloss:0.338312
## [586] train-logloss:0.337909 eval-logloss:0.337926
## [587] train-logloss:0.337577 eval-logloss:0.337595
## [588] train-logloss:0.337176 eval-logloss:0.337194
## [589] train-logloss:0.336775 eval-logloss:0.336793
## [590] train-logloss:0.336374 eval-logloss:0.336393
## [591] train-logloss:0.335975 eval-logloss:0.335993
## [592] train-logloss:0.335576 eval-logloss:0.335594
## [593] train-logloss:0.335177 eval-logloss:0.335196
## [594] train-logloss:0.334779 eval-logloss:0.334798
## [595] train-logloss:0.334381 eval-logloss:0.334400
## [596] train-logloss:0.333993 eval-logloss:0.334012
## [597] train-logloss:0.333609 eval-logloss:0.333628
## [598] train-logloss:0.333214 eval-logloss:0.333232
## [599] train-logloss:0.332818 eval-logloss:0.332837
## [600] train-logloss:0.332424 eval-logloss:0.332442
## [601] train-logloss:0.332042 eval-logloss:0.332060
## [602] train-logloss:0.331648 eval-logloss:0.331666
## [603] train-logloss:0.331255 eval-logloss:0.331273
## [604] train-logloss:0.330862 eval-logloss:0.330881
## [605] train-logloss:0.330470 eval-logloss:0.330489
## [606] train-logloss:0.330079 eval-logloss:0.330097
## [607] train-logloss:0.329697 eval-logloss:0.329715
## [608] train-logloss:0.329306 eval-logloss:0.329324
## [609] train-logloss:0.328991 eval-logloss:0.329009
## [610] train-logloss:0.328601 eval-logloss:0.328620
## [611] train-logloss:0.328212 eval-logloss:0.328231
## [612] train-logloss:0.327839 eval-logloss:0.327857
## [613] train-logloss:0.327451 eval-logloss:0.327469
## [614] train-logloss:0.327064 eval-logloss:0.327082
## [615] train-logloss:0.326864 eval-logloss:0.326882
## [616] train-logloss:0.326478 eval-logloss:0.326496
## [617] train-logloss:0.326107 eval-logloss:0.326126
## [618] train-logloss:0.325722 eval-logloss:0.325740
## [619] train-logloss:0.325337 eval-logloss:0.325355
## [620] train-logloss:0.324952 eval-logloss:0.324971
## [621] train-logloss:0.324568 eval-logloss:0.324587
## [622] train-logloss:0.324185 eval-logloss:0.324204
## [623] train-logloss:0.323982 eval-logloss:0.324001

```

```
## [624] train-logloss:0.323599 eval-logloss:0.323618
## [625] train-logloss:0.323217 eval-logloss:0.323236
## [626] train-logloss:0.322836 eval-logloss:0.322855
## [627] train-logloss:0.322471 eval-logloss:0.322490
## [628] train-logloss:0.322099 eval-logloss:0.322118
## [629] train-logloss:0.321728 eval-logloss:0.321746
## [630] train-logloss:0.321348 eval-logloss:0.321367
## [631] train-logloss:0.321037 eval-logloss:0.321057
## [632] train-logloss:0.320658 eval-logloss:0.320678
## [633] train-logloss:0.320280 eval-logloss:0.320300
## [634] train-logloss:0.319911 eval-logloss:0.319931
## [635] train-logloss:0.319712 eval-logloss:0.319732
## [636] train-logloss:0.319335 eval-logloss:0.319355
## [637] train-logloss:0.318969 eval-logloss:0.318988
## [638] train-logloss:0.318603 eval-logloss:0.318622
## [639] train-logloss:0.318228 eval-logloss:0.318247
## [640] train-logloss:0.317853 eval-logloss:0.317872
## [641] train-logloss:0.317491 eval-logloss:0.317510
## [642] train-logloss:0.317294 eval-logloss:0.317313
## [643] train-logloss:0.316930 eval-logloss:0.316949
## [644] train-logloss:0.316566 eval-logloss:0.316584
## [645] train-logloss:0.316202 eval-logloss:0.316220
## [646] train-logloss:0.315830 eval-logloss:0.315848
## [647] train-logloss:0.315459 eval-logloss:0.315477
## [648] train-logloss:0.315159 eval-logloss:0.315178
## [649] train-logloss:0.314855 eval-logloss:0.314874
## [650] train-logloss:0.314485 eval-logloss:0.314505
## [651] train-logloss:0.314115 eval-logloss:0.314135
## [652] train-logloss:0.313926 eval-logloss:0.313946
## [653] train-logloss:0.313557 eval-logloss:0.313577
## [654] train-logloss:0.313198 eval-logloss:0.313217
## [655] train-logloss:0.313004 eval-logloss:0.313023
## [656] train-logloss:0.312649 eval-logloss:0.312669
## [657] train-logloss:0.312292 eval-logloss:0.312311
## [658] train-logloss:0.311925 eval-logloss:0.311944
## [659] train-logloss:0.311559 eval-logloss:0.311579
## [660] train-logloss:0.311194 eval-logloss:0.311213
## [661] train-logloss:0.310829 eval-logloss:0.310848
## [662] train-logloss:0.310464 eval-logloss:0.310484
## [663] train-logloss:0.310100 eval-logloss:0.310120
## [664] train-logloss:0.309737 eval-logloss:0.309756
## [665] train-logloss:0.309383 eval-logloss:0.309402
## [666] train-logloss:0.309020 eval-logloss:0.309039
## [667] train-logloss:0.308658 eval-logloss:0.308677
## [668] train-logloss:0.308306 eval-logloss:0.308325
## [669] train-logloss:0.307957 eval-logloss:0.307976
## [670] train-logloss:0.307597 eval-logloss:0.307615
## [671] train-logloss:0.307246 eval-logloss:0.307264
## [672] train-logloss:0.306887 eval-logloss:0.306905
## [673] train-logloss:0.306703 eval-logloss:0.306721
## [674] train-logloss:0.306344 eval-logloss:0.306362
## [675] train-logloss:0.306132 eval-logloss:0.306151
## [676] train-logloss:0.305774 eval-logloss:0.305793
## [677] train-logloss:0.305417 eval-logloss:0.305435
```

```
## [678] train-logloss:0.305060 eval-logloss:0.305078
## [679] train-logloss:0.304703 eval-logloss:0.304722
## [680] train-logloss:0.304347 eval-logloss:0.304366
## [681] train-logloss:0.304000 eval-logloss:0.304018
## [682] train-logloss:0.303813 eval-logloss:0.303831
## [683] train-logloss:0.303466 eval-logloss:0.303484
## [684] train-logloss:0.303126 eval-logloss:0.303144
## [685] train-logloss:0.302772 eval-logloss:0.302790
## [686] train-logloss:0.302418 eval-logloss:0.302437
## [687] train-logloss:0.302065 eval-logloss:0.302084
## [688] train-logloss:0.301713 eval-logloss:0.301731
## [689] train-logloss:0.301361 eval-logloss:0.301379
## [690] train-logloss:0.301009 eval-logloss:0.301027
## [691] train-logloss:0.300670 eval-logloss:0.300689
## [692] train-logloss:0.300320 eval-logloss:0.300338
## [693] train-logloss:0.300031 eval-logloss:0.300051
## [694] train-logloss:0.299681 eval-logloss:0.299701
## [695] train-logloss:0.299341 eval-logloss:0.299361
## [696] train-logloss:0.299000 eval-logloss:0.299020
## [697] train-logloss:0.298652 eval-logloss:0.298671
## [698] train-logloss:0.298304 eval-logloss:0.298323
## [699] train-logloss:0.298024 eval-logloss:0.298044
## [700] train-logloss:0.297677 eval-logloss:0.297697
## [701] train-logloss:0.297330 eval-logloss:0.297350
## [702] train-logloss:0.297052 eval-logloss:0.297071
## [703] train-logloss:0.296706 eval-logloss:0.296726
## [704] train-logloss:0.296360 eval-logloss:0.296380
## [705] train-logloss:0.296016 eval-logloss:0.296036
## [706] train-logloss:0.295671 eval-logloss:0.295691
## [707] train-logloss:0.295335 eval-logloss:0.295355
## [708] train-logloss:0.295000 eval-logloss:0.295020
## [709] train-logloss:0.294657 eval-logloss:0.294677
## [710] train-logloss:0.294323 eval-logloss:0.294342
## [711] train-logloss:0.293989 eval-logloss:0.294008
## [712] train-logloss:0.293656 eval-logloss:0.293674
## [713] train-logloss:0.293379 eval-logloss:0.293398
## [714] train-logloss:0.293099 eval-logloss:0.293120
## [715] train-logloss:0.292759 eval-logloss:0.292780
## [716] train-logloss:0.292419 eval-logloss:0.292440
## [717] train-logloss:0.292079 eval-logloss:0.292100
## [718] train-logloss:0.291805 eval-logloss:0.291826
## [719] train-logloss:0.291466 eval-logloss:0.291487
## [720] train-logloss:0.291140 eval-logloss:0.291161
## [721] train-logloss:0.290802 eval-logloss:0.290823
## [722] train-logloss:0.290464 eval-logloss:0.290486
## [723] train-logloss:0.290127 eval-logloss:0.290149
## [724] train-logloss:0.289799 eval-logloss:0.289820
## [725] train-logloss:0.289463 eval-logloss:0.289484
## [726] train-logloss:0.289135 eval-logloss:0.289156
## [727] train-logloss:0.288800 eval-logloss:0.288821
## [728] train-logloss:0.288479 eval-logloss:0.288500
## [729] train-logloss:0.288204 eval-logloss:0.288227
## [730] train-logloss:0.288029 eval-logloss:0.288051
## [731] train-logloss:0.287755 eval-logloss:0.287779
```

```
## [732] train-logloss:0.287421 eval-logloss:0.287445
## [733] train-logloss:0.287088 eval-logloss:0.287113
## [734] train-logloss:0.286815 eval-logloss:0.286841
## [735] train-logloss:0.286546 eval-logloss:0.286572
## [736] train-logloss:0.286277 eval-logloss:0.286304
## [737] train-logloss:0.285945 eval-logloss:0.285972
## [738] train-logloss:0.285614 eval-logloss:0.285641
## [739] train-logloss:0.285292 eval-logloss:0.285319
## [740] train-logloss:0.284962 eval-logloss:0.284989
## [741] train-logloss:0.284632 eval-logloss:0.284659
## [742] train-logloss:0.284303 eval-logloss:0.284330
## [743] train-logloss:0.283982 eval-logloss:0.284008
## [744] train-logloss:0.283654 eval-logloss:0.283680
## [745] train-logloss:0.283385 eval-logloss:0.283413
## [746] train-logloss:0.283066 eval-logloss:0.283094
## [747] train-logloss:0.282739 eval-logloss:0.282767
## [748] train-logloss:0.282425 eval-logloss:0.282452
## [749] train-logloss:0.282098 eval-logloss:0.282126
## [750] train-logloss:0.281772 eval-logloss:0.281800
## [751] train-logloss:0.281455 eval-logloss:0.281483
## [752] train-logloss:0.281143 eval-logloss:0.281170
## [753] train-logloss:0.280818 eval-logloss:0.280845
## [754] train-logloss:0.280494 eval-logloss:0.280521
## [755] train-logloss:0.280170 eval-logloss:0.280197
## [756] train-logloss:0.279847 eval-logloss:0.279874
## [757] train-logloss:0.279524 eval-logloss:0.279551
## [758] train-logloss:0.279202 eval-logloss:0.279229
## [759] train-logloss:0.278880 eval-logloss:0.278907
## [760] train-logloss:0.278616 eval-logloss:0.278645
## [761] train-logloss:0.278295 eval-logloss:0.278324
## [762] train-logloss:0.277974 eval-logloss:0.278003
## [763] train-logloss:0.277812 eval-logloss:0.277840
## [764] train-logloss:0.277492 eval-logloss:0.277520
## [765] train-logloss:0.277331 eval-logloss:0.277360
## [766] train-logloss:0.277011 eval-logloss:0.277040
## [767] train-logloss:0.276700 eval-logloss:0.276728
## [768] train-logloss:0.276389 eval-logloss:0.276417
## [769] train-logloss:0.276070 eval-logloss:0.276099
## [770] train-logloss:0.275910 eval-logloss:0.275938
## [771] train-logloss:0.275600 eval-logloss:0.275628
## [772] train-logloss:0.275341 eval-logloss:0.275370
## [773] train-logloss:0.275081 eval-logloss:0.275112
## [774] train-logloss:0.274822 eval-logloss:0.274854
## [775] train-logloss:0.274564 eval-logloss:0.274598
## [776] train-logloss:0.274306 eval-logloss:0.274341
## [777] train-logloss:0.273991 eval-logloss:0.274026
## [778] train-logloss:0.273683 eval-logloss:0.273718
## [779] train-logloss:0.273368 eval-logloss:0.273403
## [780] train-logloss:0.273111 eval-logloss:0.273147
## [781] train-logloss:0.272797 eval-logloss:0.272833
## [782] train-logloss:0.272484 eval-logloss:0.272520
## [783] train-logloss:0.272231 eval-logloss:0.272268
## [784] train-logloss:0.271926 eval-logloss:0.271963
## [785] train-logloss:0.271622 eval-logloss:0.271658
```

```
## [786] train-logloss:0.271438 eval-logloss:0.271475
## [787] train-logloss:0.271127 eval-logloss:0.271163
## [788] train-logloss:0.270876 eval-logloss:0.270913
## [789] train-logloss:0.270565 eval-logloss:0.270602
## [790] train-logloss:0.270263 eval-logloss:0.270299
## [791] train-logloss:0.269952 eval-logloss:0.269989
## [792] train-logloss:0.269656 eval-logloss:0.269692
## [793] train-logloss:0.269346 eval-logloss:0.269383
## [794] train-logloss:0.269095 eval-logloss:0.269133
## [795] train-logloss:0.268786 eval-logloss:0.268824
## [796] train-logloss:0.268535 eval-logloss:0.268574
## [797] train-logloss:0.268227 eval-logloss:0.268266
## [798] train-logloss:0.267920 eval-logloss:0.267959
## [799] train-logloss:0.267612 eval-logloss:0.267651
## [800] train-logloss:0.267366 eval-logloss:0.267406
## [801] train-logloss:0.267071 eval-logloss:0.267111
## [802] train-logloss:0.266765 eval-logloss:0.266804
## [803] train-logloss:0.266467 eval-logloss:0.266506
## [804] train-logloss:0.266161 eval-logloss:0.266200
## [805] train-logloss:0.265857 eval-logloss:0.265896
## [806] train-logloss:0.265552 eval-logloss:0.265591
## [807] train-logloss:0.265256 eval-logloss:0.265295
## [808] train-logloss:0.264960 eval-logloss:0.264999
## [809] train-logloss:0.264671 eval-logloss:0.264709
## [810] train-logloss:0.264368 eval-logloss:0.264406
## [811] train-logloss:0.264066 eval-logloss:0.264104
## [812] train-logloss:0.263763 eval-logloss:0.263802
## [813] train-logloss:0.263473 eval-logloss:0.263511
## [814] train-logloss:0.263172 eval-logloss:0.263209
## [815] train-logloss:0.262871 eval-logloss:0.262908
## [816] train-logloss:0.262570 eval-logloss:0.262608
## [817] train-logloss:0.262278 eval-logloss:0.262315
## [818] train-logloss:0.261978 eval-logloss:0.262015
## [819] train-logloss:0.261686 eval-logloss:0.261723
## [820] train-logloss:0.261394 eval-logloss:0.261431
## [821] train-logloss:0.261151 eval-logloss:0.261189
## [822] train-logloss:0.260853 eval-logloss:0.260891
## [823] train-logloss:0.260555 eval-logloss:0.260593
## [824] train-logloss:0.260257 eval-logloss:0.260295
## [825] train-logloss:0.260105 eval-logloss:0.260144
## [826] train-logloss:0.259816 eval-logloss:0.259854
## [827] train-logloss:0.259519 eval-logloss:0.259558
## [828] train-logloss:0.259223 eval-logloss:0.259261
## [829] train-logloss:0.258927 eval-logloss:0.258965
## [830] train-logloss:0.258631 eval-logloss:0.258670
## [831] train-logloss:0.258336 eval-logloss:0.258375
## [832] train-logloss:0.258041 eval-logloss:0.258080
## [833] train-logloss:0.257754 eval-logloss:0.257793
## [834] train-logloss:0.257460 eval-logloss:0.257499
## [835] train-logloss:0.257167 eval-logloss:0.257205
## [836] train-logloss:0.256881 eval-logloss:0.256919
## [837] train-logloss:0.256600 eval-logloss:0.256637
## [838] train-logloss:0.256318 eval-logloss:0.256356
## [839] train-logloss:0.256169 eval-logloss:0.256206
```

```

## [840] train-logloss:0.255877 eval-logloss:0.255915
## [841] train-logloss:0.255585 eval-logloss:0.255623
## [842] train-logloss:0.255348 eval-logloss:0.255387
## [843] train-logloss:0.255057 eval-logloss:0.255097
## [844] train-logloss:0.254767 eval-logloss:0.254806
## [845] train-logloss:0.254477 eval-logloss:0.254516
## [846] train-logloss:0.254187 eval-logloss:0.254226
## [847] train-logloss:0.253905 eval-logloss:0.253944
## [848] train-logloss:0.253616 eval-logloss:0.253655
## [849] train-logloss:0.253327 eval-logloss:0.253366
## [850] train-logloss:0.253039 eval-logloss:0.253078
## [851] train-logloss:0.252808 eval-logloss:0.252847
## [852] train-logloss:0.252520 eval-logloss:0.252560
## [853] train-logloss:0.252241 eval-logloss:0.252280
## [854] train-logloss:0.251954 eval-logloss:0.251993
## [855] train-logloss:0.251667 eval-logloss:0.251706
## [856] train-logloss:0.251381 eval-logloss:0.251420
## [857] train-logloss:0.251095 eval-logloss:0.251135
## [858] train-logloss:0.250817 eval-logloss:0.250856
## [859] train-logloss:0.250532 eval-logloss:0.250571
## [860] train-logloss:0.250247 eval-logloss:0.250287
## [861] train-logloss:0.249963 eval-logloss:0.250002
## [862] train-logloss:0.249679 eval-logloss:0.249718
## [863] train-logloss:0.249395 eval-logloss:0.249435
## [864] train-logloss:0.249248 eval-logloss:0.249288
## [865] train-logloss:0.248965 eval-logloss:0.249005
## [866] train-logloss:0.248683 eval-logloss:0.248722
## [867] train-logloss:0.248412 eval-logloss:0.248452
## [868] train-logloss:0.248130 eval-logloss:0.248170
## [869] train-logloss:0.247849 eval-logloss:0.247888
## [870] train-logloss:0.247567 eval-logloss:0.247607
## [871] train-logloss:0.247422 eval-logloss:0.247462
## [872] train-logloss:0.247141 eval-logloss:0.247181
## [873] train-logloss:0.246861 eval-logloss:0.246901
## [874] train-logloss:0.246635 eval-logloss:0.246676
## [875] train-logloss:0.246356 eval-logloss:0.246396
## [876] train-logloss:0.246129 eval-logloss:0.246171
## [877] train-logloss:0.245850 eval-logloss:0.245892
## [878] train-logloss:0.245580 eval-logloss:0.245621
## [879] train-logloss:0.245308 eval-logloss:0.245350
## [880] train-logloss:0.245030 eval-logloss:0.245072
## [881] train-logloss:0.244753 eval-logloss:0.244794
## [882] train-logloss:0.244486 eval-logloss:0.244527
## [883] train-logloss:0.244209 eval-logloss:0.244250
## [884] train-logloss:0.243944 eval-logloss:0.243986
## [885] train-logloss:0.243668 eval-logloss:0.243709
## [886] train-logloss:0.243399 eval-logloss:0.243440
## [887] train-logloss:0.243123 eval-logloss:0.243164
## [888] train-logloss:0.242848 eval-logloss:0.242889
## [889] train-logloss:0.242581 eval-logloss:0.242621
## [890] train-logloss:0.242314 eval-logloss:0.242354
## [891] train-logloss:0.242040 eval-logloss:0.242080
## [892] train-logloss:0.241766 eval-logloss:0.241806
## [893] train-logloss:0.241492 eval-logloss:0.241533

```

```
## [894] train-logloss:0.241226 eval-logloss:0.241266
## [895] train-logloss:0.240953 eval-logloss:0.240993
## [896] train-logloss:0.240681 eval-logloss:0.240721
## [897] train-logloss:0.240409 eval-logloss:0.240449
## [898] train-logloss:0.240272 eval-logloss:0.240312
## [899] train-logloss:0.240052 eval-logloss:0.240093
## [900] train-logloss:0.239781 eval-logloss:0.239822
## [901] train-logloss:0.239510 eval-logloss:0.239551
## [902] train-logloss:0.239239 eval-logloss:0.239280
## [903] train-logloss:0.238969 eval-logloss:0.239010
## [904] train-logloss:0.238699 eval-logloss:0.238740
## [905] train-logloss:0.238482 eval-logloss:0.238524
## [906] train-logloss:0.238220 eval-logloss:0.238262
## [907] train-logloss:0.237962 eval-logloss:0.238003
## [908] train-logloss:0.237693 eval-logloss:0.237735
## [909] train-logloss:0.237559 eval-logloss:0.237601
## [910] train-logloss:0.237303 eval-logloss:0.237345
## [911] train-logloss:0.237036 eval-logloss:0.237077
## [912] train-logloss:0.236768 eval-logloss:0.236809
## [913] train-logloss:0.236501 eval-logloss:0.236542
## [914] train-logloss:0.236285 eval-logloss:0.236327
## [915] train-logloss:0.236028 eval-logloss:0.236070
## [916] train-logloss:0.235761 eval-logloss:0.235804
## [917] train-logloss:0.235503 eval-logloss:0.235546
## [918] train-logloss:0.235248 eval-logloss:0.235290
## [919] train-logloss:0.234982 eval-logloss:0.235025
## [920] train-logloss:0.234717 eval-logloss:0.234760
## [921] train-logloss:0.234581 eval-logloss:0.234623
## [922] train-logloss:0.234328 eval-logloss:0.234370
## [923] train-logloss:0.234064 eval-logloss:0.234106
## [924] train-logloss:0.233800 eval-logloss:0.233842
## [925] train-logloss:0.233537 eval-logloss:0.233579
## [926] train-logloss:0.233274 eval-logloss:0.233316
## [927] train-logloss:0.233063 eval-logloss:0.233105
## [928] train-logloss:0.232800 eval-logloss:0.232843
## [929] train-logloss:0.232545 eval-logloss:0.232587
## [930] train-logloss:0.232283 eval-logloss:0.232326
## [931] train-logloss:0.232022 eval-logloss:0.232064
## [932] train-logloss:0.231767 eval-logloss:0.231809
## [933] train-logloss:0.231507 eval-logloss:0.231549
## [934] train-logloss:0.231246 eval-logloss:0.231288
## [935] train-logloss:0.230986 eval-logloss:0.231028
## [936] train-logloss:0.230737 eval-logloss:0.230778
## [937] train-logloss:0.230490 eval-logloss:0.230532
## [938] train-logloss:0.230231 eval-logloss:0.230272
## [939] train-logloss:0.229972 eval-logloss:0.230013
## [940] train-logloss:0.229721 eval-logloss:0.229762
## [941] train-logloss:0.229463 eval-logloss:0.229504
## [942] train-logloss:0.229205 eval-logloss:0.229246
## [943] train-logloss:0.229076 eval-logloss:0.229118
## [944] train-logloss:0.228946 eval-logloss:0.228987
## [945] train-logloss:0.228695 eval-logloss:0.228736
## [946] train-logloss:0.228445 eval-logloss:0.228486
## [947] train-logloss:0.228198 eval-logloss:0.228239
```

```

## [948] train-logloss:0.227949 eval-logloss:0.227989
## [949] train-logloss:0.227742 eval-logloss:0.227784
## [950] train-logloss:0.227486 eval-logloss:0.227528
## [951] train-logloss:0.227238 eval-logloss:0.227280
## [952] train-logloss:0.226990 eval-logloss:0.227031
## [953] train-logloss:0.226741 eval-logloss:0.226782
## [954] train-logloss:0.226494 eval-logloss:0.226535
## [955] train-logloss:0.226240 eval-logloss:0.226281
## [956] train-logloss:0.225986 eval-logloss:0.226027
## [957] train-logloss:0.225733 eval-logloss:0.225773
## [958] train-logloss:0.225486 eval-logloss:0.225526
## [959] train-logloss:0.225233 eval-logloss:0.225274
## [960] train-logloss:0.224988 eval-logloss:0.225028
## [961] train-logloss:0.224736 eval-logloss:0.224776
## [962] train-logloss:0.224491 eval-logloss:0.224530
## [963] train-logloss:0.224246 eval-logloss:0.224285
## [964] train-logloss:0.223995 eval-logloss:0.224034
## [965] train-logloss:0.223743 eval-logloss:0.223783
## [966] train-logloss:0.223503 eval-logloss:0.223543
## [967] train-logloss:0.223301 eval-logloss:0.223341
## [968] train-logloss:0.223051 eval-logloss:0.223091
## [969] train-logloss:0.222801 eval-logloss:0.222841
## [970] train-logloss:0.222551 eval-logloss:0.222592
## [971] train-logloss:0.222302 eval-logloss:0.222342
## [972] train-logloss:0.222174 eval-logloss:0.222215
## [973] train-logloss:0.221925 eval-logloss:0.221966
## [974] train-logloss:0.221677 eval-logloss:0.221717
## [975] train-logloss:0.221429 eval-logloss:0.221469
## [976] train-logloss:0.221188 eval-logloss:0.221229
## [977] train-logloss:0.220941 eval-logloss:0.220981
## [978] train-logloss:0.220693 eval-logloss:0.220734
## [979] train-logloss:0.220446 eval-logloss:0.220487
## [980] train-logloss:0.220320 eval-logloss:0.220361
## [981] train-logloss:0.220074 eval-logloss:0.220115
## [982] train-logloss:0.219828 eval-logloss:0.219869
## [983] train-logloss:0.219582 eval-logloss:0.219623
## [984] train-logloss:0.219343 eval-logloss:0.219384
## [985] train-logloss:0.219098 eval-logloss:0.219139
## [986] train-logloss:0.218853 eval-logloss:0.218894
## [987] train-logloss:0.218618 eval-logloss:0.218659
## [988] train-logloss:0.218374 eval-logloss:0.218415
## [989] train-logloss:0.218130 eval-logloss:0.218171
## [990] train-logloss:0.217886 eval-logloss:0.217927
## [991] train-logloss:0.217643 eval-logloss:0.217684
## [992] train-logloss:0.217400 eval-logloss:0.217441
## [993] train-logloss:0.217157 eval-logloss:0.217198
## [994] train-logloss:0.216914 eval-logloss:0.216955
## [995] train-logloss:0.216672 eval-logloss:0.216713
## [996] train-logloss:0.216548 eval-logloss:0.216589
## [997] train-logloss:0.216306 eval-logloss:0.216347
## [998] train-logloss:0.216182 eval-logloss:0.216224
## [999] train-logloss:0.215941 eval-logloss:0.215983
## [1000] train-logloss:0.215700 eval-logloss:0.215742
## [1] train-logloss:0.683199 eval-logloss:0.683199

```

```

## Multiple eval metrics are present. Will use eval_logloss for early stopping.
## Will train until eval_logloss hasn't improved in 10 rounds.
##
## [2]  train-logloss:0.673776  eval-logloss:0.673773
## [3]  train-logloss:0.664539  eval-logloss:0.664531
## [4]  train-logloss:0.655152  eval-logloss:0.655144
## [5]  train-logloss:0.645945  eval-logloss:0.645938
## [6]  train-logloss:0.637302  eval-logloss:0.637290
## [7]  train-logloss:0.628434  eval-logloss:0.628422
## [8]  train-logloss:0.620114  eval-logloss:0.620097
## [9]  train-logloss:0.611948  eval-logloss:0.611927
## [10] train-logloss:0.603862  eval-logloss:0.603838
## [11] train-logloss:0.595993  eval-logloss:0.595965
## [12] train-logloss:0.587887  eval-logloss:0.587859
## [13] train-logloss:0.580233  eval-logloss:0.580202
## [14] train-logloss:0.572716  eval-logloss:0.572681
## [15] train-logloss:0.565025  eval-logloss:0.564990
## [16] train-logloss:0.561027  eval-logloss:0.560972
## [17] train-logloss:0.553906  eval-logloss:0.553847
## [18] train-logloss:0.546544  eval-logloss:0.546486
## [19] train-logloss:0.539308  eval-logloss:0.539251
## [20] train-logloss:0.532551  eval-logloss:0.532490
## [21] train-logloss:0.525909  eval-logloss:0.525845
## [22] train-logloss:0.521437  eval-logloss:0.521362
## [23] train-logloss:0.517044  eval-logloss:0.516961
## [24] train-logloss:0.510601  eval-logloss:0.510515
## [25] train-logloss:0.504327  eval-logloss:0.504238
## [26] train-logloss:0.497800  eval-logloss:0.497713
## [27] train-logloss:0.491672  eval-logloss:0.491582
## [28] train-logloss:0.488406  eval-logloss:0.488303
## [29] train-logloss:0.482429  eval-logloss:0.482324
## [30] train-logloss:0.476608  eval-logloss:0.476500
## [31] train-logloss:0.470532  eval-logloss:0.470424
## [32] train-logloss:0.464840  eval-logloss:0.464731
## [33] train-logloss:0.461745  eval-logloss:0.461630
## [34] train-logloss:0.456192  eval-logloss:0.456075
## [35] train-logloss:0.450438  eval-logloss:0.450323
## [36] train-logloss:0.444775  eval-logloss:0.444661
## [37] train-logloss:0.439479  eval-logloss:0.439364
## [38] train-logloss:0.434266  eval-logloss:0.434149
## [39] train-logloss:0.429134  eval-logloss:0.429015
## [40] train-logloss:0.424081  eval-logloss:0.423960
## [41] train-logloss:0.419106  eval-logloss:0.418983
## [42] train-logloss:0.413924  eval-logloss:0.413803
## [43] train-logloss:0.408821  eval-logloss:0.408701
## [44] train-logloss:0.406231  eval-logloss:0.406107
## [45] train-logloss:0.401567  eval-logloss:0.401440
## [46] train-logloss:0.396647  eval-logloss:0.396522
## [47] train-logloss:0.392122  eval-logloss:0.391993
## [48] train-logloss:0.387664  eval-logloss:0.387533
## [49] train-logloss:0.383271  eval-logloss:0.383138
## [50] train-logloss:0.378944  eval-logloss:0.378808
## [51] train-logloss:0.374357  eval-logloss:0.374222
## [52] train-logloss:0.370108  eval-logloss:0.369971

```

```

## [53] train-logloss:0.365920 eval-logloss:0.365782
## [54] train-logloss:0.361840 eval-logloss:0.361700
## [55] train-logloss:0.359633 eval-logloss:0.359485
## [56] train-logloss:0.357002 eval-logloss:0.356843
## [57] train-logloss:0.354399 eval-logloss:0.354236
## [58] train-logloss:0.351838 eval-logloss:0.351668
## [59] train-logloss:0.347912 eval-logloss:0.347741
## [60] train-logloss:0.343766 eval-logloss:0.343598
## [61] train-logloss:0.339952 eval-logloss:0.339781
## [62] train-logloss:0.337964 eval-logloss:0.337789
## [63] train-logloss:0.333958 eval-logloss:0.333785
## [64] train-logloss:0.330278 eval-logloss:0.330103
## [65] train-logloss:0.327961 eval-logloss:0.327782
## [66] train-logloss:0.324408 eval-logloss:0.324226
## [67] train-logloss:0.320905 eval-logloss:0.320720
## [68] train-logloss:0.317450 eval-logloss:0.317263
## [69] train-logloss:0.313999 eval-logloss:0.313811
## [70] train-logloss:0.310595 eval-logloss:0.310407
## [71] train-logloss:0.308468 eval-logloss:0.308275
## [72] train-logloss:0.305140 eval-logloss:0.304946
## [73] train-logloss:0.301858 eval-logloss:0.301663
## [74] train-logloss:0.298621 eval-logloss:0.298424
## [75] train-logloss:0.295468 eval-logloss:0.295270
## [76] train-logloss:0.292042 eval-logloss:0.291846
## [77] train-logloss:0.288934 eval-logloss:0.288737
## [78] train-logloss:0.285595 eval-logloss:0.285400
## [79] train-logloss:0.282610 eval-logloss:0.282413
## [80] train-logloss:0.279665 eval-logloss:0.279467
## [81] train-logloss:0.276449 eval-logloss:0.276252
## [82] train-logloss:0.273583 eval-logloss:0.273384
## [83] train-logloss:0.270755 eval-logloss:0.270554
## [84] train-logloss:0.267926 eval-logloss:0.267724
## [85] train-logloss:0.265172 eval-logloss:0.264969
## [86] train-logloss:0.262455 eval-logloss:0.262249
## [87] train-logloss:0.259774 eval-logloss:0.259566
## [88] train-logloss:0.258409 eval-logloss:0.258193
## [89] train-logloss:0.255468 eval-logloss:0.255255
## [90] train-logloss:0.252875 eval-logloss:0.252659
## [91] train-logloss:0.250006 eval-logloss:0.249793
## [92] train-logloss:0.247479 eval-logloss:0.247265
## [93] train-logloss:0.244679 eval-logloss:0.244467
## [94] train-logloss:0.242219 eval-logloss:0.242004
## [95] train-logloss:0.239753 eval-logloss:0.239538
## [96] train-logloss:0.237318 eval-logloss:0.237102
## [97] train-logloss:0.234952 eval-logloss:0.234733
## [98] train-logloss:0.232616 eval-logloss:0.232395
## [99] train-logloss:0.230272 eval-logloss:0.230051
## [100] train-logloss:0.227960 eval-logloss:0.227737
## [101] train-logloss:0.225712 eval-logloss:0.225487
## [102] train-logloss:0.223186 eval-logloss:0.222964
## [103] train-logloss:0.221799 eval-logloss:0.221572
## [104] train-logloss:0.219322 eval-logloss:0.219097
## [105] train-logloss:0.218231 eval-logloss:0.218005
## [106] train-logloss:0.215798 eval-logloss:0.215574

```

```

## [107] train-logloss:0.213695 eval-logloss:0.213469
## [108] train-logloss:0.211317 eval-logloss:0.211094
## [109] train-logloss:0.209232 eval-logloss:0.209008
## [110] train-logloss:0.207173 eval-logloss:0.206947
## [111] train-logloss:0.205174 eval-logloss:0.204946
## [112] train-logloss:0.203199 eval-logloss:0.202970
## [113] train-logloss:0.201215 eval-logloss:0.200985
## [114] train-logloss:0.200132 eval-logloss:0.199898
## [115] train-logloss:0.198186 eval-logloss:0.197951
## [116] train-logloss:0.195999 eval-logloss:0.195765
## [117] train-logloss:0.194101 eval-logloss:0.193867
## [118] train-logloss:0.192228 eval-logloss:0.191992
## [119] train-logloss:0.190409 eval-logloss:0.190172
## [120] train-logloss:0.189500 eval-logloss:0.189259
## [121] train-logloss:0.187682 eval-logloss:0.187441
## [122] train-logloss:0.185920 eval-logloss:0.185676
## [123] train-logloss:0.183880 eval-logloss:0.183638
## [124] train-logloss:0.182128 eval-logloss:0.181887
## [125] train-logloss:0.180430 eval-logloss:0.180187
## [126] train-logloss:0.178456 eval-logloss:0.178215
## [127] train-logloss:0.176505 eval-logloss:0.176267
## [128] train-logloss:0.174839 eval-logloss:0.174600
## [129] train-logloss:0.172931 eval-logloss:0.172694
## [130] train-logloss:0.171045 eval-logloss:0.170811
## [131] train-logloss:0.169182 eval-logloss:0.168950
## [132] train-logloss:0.167627 eval-logloss:0.167394
## [133] train-logloss:0.166061 eval-logloss:0.165827
## [134] train-logloss:0.164514 eval-logloss:0.164279
## [135] train-logloss:0.162728 eval-logloss:0.162495
## [136] train-logloss:0.161218 eval-logloss:0.160984
## [137] train-logloss:0.159470 eval-logloss:0.159239
## [138] train-logloss:0.157743 eval-logloss:0.157514
## [139] train-logloss:0.156317 eval-logloss:0.156086
## [140] train-logloss:0.154879 eval-logloss:0.154647
## [141] train-logloss:0.153487 eval-logloss:0.153253
## [142] train-logloss:0.151829 eval-logloss:0.151597
## [143] train-logloss:0.150442 eval-logloss:0.150210
## [144] train-logloss:0.148820 eval-logloss:0.148590
## [145] train-logloss:0.147216 eval-logloss:0.146988
## [146] train-logloss:0.145630 eval-logloss:0.145405
## [147] train-logloss:0.144310 eval-logloss:0.144084
## [148] train-logloss:0.143006 eval-logloss:0.142779
## [149] train-logloss:0.141744 eval-logloss:0.141515
## [150] train-logloss:0.140221 eval-logloss:0.139994
## [151] train-logloss:0.138990 eval-logloss:0.138761
## [152] train-logloss:0.137746 eval-logloss:0.137516
## [153] train-logloss:0.136543 eval-logloss:0.136312
## [154] train-logloss:0.135932 eval-logloss:0.135699
## [155] train-logloss:0.134475 eval-logloss:0.134244
## [156] train-logloss:0.133035 eval-logloss:0.132807
## [157] train-logloss:0.132450 eval-logloss:0.132219
## [158] train-logloss:0.131304 eval-logloss:0.131072
## [159] train-logloss:0.130146 eval-logloss:0.129913
## [160] train-logloss:0.129028 eval-logloss:0.128792

```

```

## [161] train-logloss:0.127922 eval-logloss:0.127685
## [162] train-logloss:0.126804 eval-logloss:0.126566
## [163] train-logloss:0.125699 eval-logloss:0.125460
## [164] train-logloss:0.125043 eval-logloss:0.124800
## [165] train-logloss:0.123984 eval-logloss:0.123739
## [166] train-logloss:0.122662 eval-logloss:0.122419
## [167] train-logloss:0.121603 eval-logloss:0.121359
## [168] train-logloss:0.120581 eval-logloss:0.120336
## [169] train-logloss:0.119298 eval-logloss:0.119055
## [170] train-logloss:0.118275 eval-logloss:0.118031
## [171] train-logloss:0.117669 eval-logloss:0.117424
## [172] train-logloss:0.116666 eval-logloss:0.116419
## [173] train-logloss:0.115674 eval-logloss:0.115427
## [174] train-logloss:0.114693 eval-logloss:0.114445
## [175] train-logloss:0.113749 eval-logloss:0.113499
## [176] train-logloss:0.112816 eval-logloss:0.112564
## [177] train-logloss:0.111868 eval-logloss:0.111616
## [178] train-logloss:0.110957 eval-logloss:0.110703
## [179] train-logloss:0.109780 eval-logloss:0.109528
## [180] train-logloss:0.108866 eval-logloss:0.108613
## [181] train-logloss:0.107962 eval-logloss:0.107709
## [182] train-logloss:0.107068 eval-logloss:0.106814
## [183] train-logloss:0.106185 eval-logloss:0.105930
## [184] train-logloss:0.105336 eval-logloss:0.105079
## [185] train-logloss:0.104473 eval-logloss:0.104215
## [186] train-logloss:0.103620 eval-logloss:0.103361
## [187] train-logloss:0.102800 eval-logloss:0.102539
## [188] train-logloss:0.101713 eval-logloss:0.101455
## [189] train-logloss:0.100638 eval-logloss:0.100382
## [190] train-logloss:0.099824 eval-logloss:0.099567
## [191] train-logloss:0.099043 eval-logloss:0.098784
## [192] train-logloss:0.098247 eval-logloss:0.097988
## [193] train-logloss:0.097778 eval-logloss:0.097518
## [194] train-logloss:0.096997 eval-logloss:0.096736
## [195] train-logloss:0.095973 eval-logloss:0.095715
## [196] train-logloss:0.095211 eval-logloss:0.094951
## [197] train-logloss:0.094846 eval-logloss:0.094584
## [198] train-logloss:0.094119 eval-logloss:0.093855
## [199] train-logloss:0.093126 eval-logloss:0.092865
## [200] train-logloss:0.092417 eval-logloss:0.092153
## [201] train-logloss:0.091996 eval-logloss:0.091731
## [202] train-logloss:0.091648 eval-logloss:0.091383
## [203] train-logloss:0.090933 eval-logloss:0.090667
## [204] train-logloss:0.090226 eval-logloss:0.089959
## [205] train-logloss:0.089824 eval-logloss:0.089556
## [206] train-logloss:0.089130 eval-logloss:0.088861
## [207] train-logloss:0.088191 eval-logloss:0.087924
## [208] train-logloss:0.087513 eval-logloss:0.087245
## [209] train-logloss:0.086865 eval-logloss:0.086595
## [210] train-logloss:0.086201 eval-logloss:0.085931
## [211] train-logloss:0.085294 eval-logloss:0.085026
## [212] train-logloss:0.084396 eval-logloss:0.084131
## [213] train-logloss:0.083508 eval-logloss:0.083245
## [214] train-logloss:0.082876 eval-logloss:0.082613

```

```
## [215] train-logloss:0.082252 eval-logloss:0.081988
## [216] train-logloss:0.081656 eval-logloss:0.081390
## [217] train-logloss:0.081045 eval-logloss:0.080779
## [218] train-logloss:0.080193 eval-logloss:0.079929
## [219] train-logloss:0.079618 eval-logloss:0.079352
## [220] train-logloss:0.079028 eval-logloss:0.078762
## [221] train-logloss:0.078197 eval-logloss:0.077933
## [222] train-logloss:0.077643 eval-logloss:0.077377
## [223] train-logloss:0.076826 eval-logloss:0.076563
## [224] train-logloss:0.076505 eval-logloss:0.076242
## [225] train-logloss:0.076188 eval-logloss:0.075922
## [226] train-logloss:0.075633 eval-logloss:0.075368
## [227] train-logloss:0.075084 eval-logloss:0.074818
## [228] train-logloss:0.074563 eval-logloss:0.074295
## [229] train-logloss:0.074026 eval-logloss:0.073759
## [230] train-logloss:0.073517 eval-logloss:0.073248
## [231] train-logloss:0.072992 eval-logloss:0.072724
## [232] train-logloss:0.072692 eval-logloss:0.072424
## [233] train-logloss:0.071928 eval-logloss:0.071662
## [234] train-logloss:0.071171 eval-logloss:0.070908
## [235] train-logloss:0.070662 eval-logloss:0.070399
## [236] train-logloss:0.070160 eval-logloss:0.069896
## [237] train-logloss:0.069663 eval-logloss:0.069399
## [238] train-logloss:0.069385 eval-logloss:0.069122
## [239] train-logloss:0.068655 eval-logloss:0.068394
## [240] train-logloss:0.068182 eval-logloss:0.067921
## [241] train-logloss:0.067915 eval-logloss:0.067653
## [242] train-logloss:0.067451 eval-logloss:0.067187
## [243] train-logloss:0.066982 eval-logloss:0.066718
## [244] train-logloss:0.066753 eval-logloss:0.066489
## [245] train-logloss:0.066050 eval-logloss:0.065789
## [246] train-logloss:0.065595 eval-logloss:0.065333
## [247] train-logloss:0.065385 eval-logloss:0.065124
## [248] train-logloss:0.064937 eval-logloss:0.064676
## [249] train-logloss:0.064495 eval-logloss:0.064233
## [250] train-logloss:0.063816 eval-logloss:0.063557
## [251] train-logloss:0.063615 eval-logloss:0.063357
## [252] train-logloss:0.063185 eval-logloss:0.062927
## [253] train-logloss:0.062770 eval-logloss:0.062512
## [254] train-logloss:0.062109 eval-logloss:0.061853
## [255] train-logloss:0.061917 eval-logloss:0.061662
## [256] train-logloss:0.061504 eval-logloss:0.061249
## [257] train-logloss:0.060856 eval-logloss:0.060603
## [258] train-logloss:0.060453 eval-logloss:0.060200
## [259] train-logloss:0.060054 eval-logloss:0.059801
## [260] train-logloss:0.059420 eval-logloss:0.059170
## [261] train-logloss:0.058793 eval-logloss:0.058546
## [262] train-logloss:0.058419 eval-logloss:0.058170
## [263] train-logloss:0.058039 eval-logloss:0.057789
## [264] train-logloss:0.057426 eval-logloss:0.057179
## [265] train-logloss:0.056820 eval-logloss:0.056576
## [266] train-logloss:0.056463 eval-logloss:0.056219
## [267] train-logloss:0.055867 eval-logloss:0.055625
## [268] train-logloss:0.055700 eval-logloss:0.055458
```

```
## [269] train-logloss:0.055343 eval-logloss:0.055101
## [270] train-logloss:0.054998 eval-logloss:0.054755
## [271] train-logloss:0.054417 eval-logloss:0.054176
## [272] train-logloss:0.054234 eval-logloss:0.053996
## [273] train-logloss:0.053889 eval-logloss:0.053650
## [274] train-logloss:0.053319 eval-logloss:0.053083
## [275] train-logloss:0.052984 eval-logloss:0.052748
## [276] train-logloss:0.052423 eval-logloss:0.052190
## [277] train-logloss:0.051868 eval-logloss:0.051637
## [278] train-logloss:0.051564 eval-logloss:0.051332
## [279] train-logloss:0.051254 eval-logloss:0.051021
## [280] train-logloss:0.051105 eval-logloss:0.050873
## [281] train-logloss:0.050800 eval-logloss:0.050567
## [282] train-logloss:0.050486 eval-logloss:0.050253
## [283] train-logloss:0.050177 eval-logloss:0.049943
## [284] train-logloss:0.049870 eval-logloss:0.049637
## [285] train-logloss:0.049569 eval-logloss:0.049335
## [286] train-logloss:0.049042 eval-logloss:0.048811
## [287] train-logloss:0.048758 eval-logloss:0.048527
## [288] train-logloss:0.048465 eval-logloss:0.048234
## [289] train-logloss:0.048176 eval-logloss:0.047944
## [290] train-logloss:0.048059 eval-logloss:0.047829
## [291] train-logloss:0.047775 eval-logloss:0.047544
## [292] train-logloss:0.047266 eval-logloss:0.047038
## [293] train-logloss:0.046988 eval-logloss:0.046759
## [294] train-logloss:0.046858 eval-logloss:0.046629
## [295] train-logloss:0.046734 eval-logloss:0.046505
## [296] train-logloss:0.046474 eval-logloss:0.046243
## [297] train-logloss:0.046339 eval-logloss:0.046109
## [298] train-logloss:0.046070 eval-logloss:0.045841
## [299] train-logloss:0.045805 eval-logloss:0.045576
## [300] train-logloss:0.045688 eval-logloss:0.045459
## [301] train-logloss:0.045200 eval-logloss:0.044974
## [302] train-logloss:0.044942 eval-logloss:0.044716
## [303] train-logloss:0.044699 eval-logloss:0.044471
## [304] train-logloss:0.044583 eval-logloss:0.044356
## [305] train-logloss:0.044107 eval-logloss:0.043882
## [306] train-logloss:0.043859 eval-logloss:0.043634
## [307] train-logloss:0.043613 eval-logloss:0.043388
## [308] train-logloss:0.043371 eval-logloss:0.043146
## [309] train-logloss:0.043131 eval-logloss:0.042906
## [310] train-logloss:0.042893 eval-logloss:0.042668
## [311] train-logloss:0.042658 eval-logloss:0.042433
## [312] train-logloss:0.042201 eval-logloss:0.041978
## [313] train-logloss:0.042095 eval-logloss:0.041873
## [314] train-logloss:0.041644 eval-logloss:0.041424
## [315] train-logloss:0.041196 eval-logloss:0.040979
## [316] train-logloss:0.041095 eval-logloss:0.040878
## [317] train-logloss:0.040873 eval-logloss:0.040657
## [318] train-logloss:0.040434 eval-logloss:0.040220
## [319] train-logloss:0.039999 eval-logloss:0.039787
## [320] train-logloss:0.039786 eval-logloss:0.039574
## [321] train-logloss:0.039594 eval-logloss:0.039380
## [322] train-logloss:0.039385 eval-logloss:0.039171
```

```
## [323] train-logloss:0.039178 eval-logloss:0.038964
## [324] train-logloss:0.038973 eval-logloss:0.038759
## [325] train-logloss:0.038552 eval-logloss:0.038341
## [326] train-logloss:0.038136 eval-logloss:0.037927
## [327] train-logloss:0.038045 eval-logloss:0.037838
## [328] train-logloss:0.037862 eval-logloss:0.037653
## [329] train-logloss:0.037667 eval-logloss:0.037458
## [330] train-logloss:0.037475 eval-logloss:0.037266
## [331] train-logloss:0.037285 eval-logloss:0.037076
## [332] train-logloss:0.037195 eval-logloss:0.036986
## [333] train-logloss:0.037007 eval-logloss:0.036799
## [334] train-logloss:0.036822 eval-logloss:0.036613
## [335] train-logloss:0.036657 eval-logloss:0.036447
## [336] train-logloss:0.036476 eval-logloss:0.036265
## [337] train-logloss:0.036296 eval-logloss:0.036085
## [338] train-logloss:0.036224 eval-logloss:0.036014
## [339] train-logloss:0.036161 eval-logloss:0.035952
## [340] train-logloss:0.035997 eval-logloss:0.035789
## [341] train-logloss:0.035816 eval-logloss:0.035607
## [342] train-logloss:0.035634 eval-logloss:0.035424
## [343] train-logloss:0.035454 eval-logloss:0.035243
## [344] train-logloss:0.035294 eval-logloss:0.035081
## [345] train-logloss:0.035130 eval-logloss:0.034917
## [346] train-logloss:0.034956 eval-logloss:0.034742
## [347] train-logloss:0.034573 eval-logloss:0.034362
## [348] train-logloss:0.034403 eval-logloss:0.034191
## [349] train-logloss:0.034237 eval-logloss:0.034024
## [350] train-logloss:0.034070 eval-logloss:0.033857
## [351] train-logloss:0.033999 eval-logloss:0.033788
## [352] train-logloss:0.033626 eval-logloss:0.033417
## [353] train-logloss:0.033464 eval-logloss:0.033255
## [354] train-logloss:0.033096 eval-logloss:0.032889
## [355] train-logloss:0.033038 eval-logloss:0.032832
## [356] train-logloss:0.032880 eval-logloss:0.032674
## [357] train-logloss:0.032743 eval-logloss:0.032534
## [358] train-logloss:0.032382 eval-logloss:0.032176
## [359] train-logloss:0.032316 eval-logloss:0.032111
## [360] train-logloss:0.031960 eval-logloss:0.031757
## [361] train-logloss:0.031895 eval-logloss:0.031694
## [362] train-logloss:0.031836 eval-logloss:0.031634
## [363] train-logloss:0.031485 eval-logloss:0.031286
## [364] train-logloss:0.031351 eval-logloss:0.031152
## [365] train-logloss:0.031005 eval-logloss:0.030808
## [366] train-logloss:0.030662 eval-logloss:0.030468
## [367] train-logloss:0.030534 eval-logloss:0.030339
## [368] train-logloss:0.030196 eval-logloss:0.030004
## [369] train-logloss:0.029862 eval-logloss:0.029672
## [370] train-logloss:0.029532 eval-logloss:0.029344
## [371] train-logloss:0.029205 eval-logloss:0.029020
## [372] train-logloss:0.028881 eval-logloss:0.028699
## [373] train-logloss:0.028824 eval-logloss:0.028642
## [374] train-logloss:0.028505 eval-logloss:0.028325
## [375] train-logloss:0.028190 eval-logloss:0.028012
## [376] train-logloss:0.028135 eval-logloss:0.027957
```

```
## [377] train-logloss:0.027823 eval-logloss:0.027648
## [378] train-logloss:0.027716 eval-logloss:0.027539
## [379] train-logloss:0.027409 eval-logloss:0.027234
## [380] train-logloss:0.027105 eval-logloss:0.026932
## [381] train-logloss:0.026804 eval-logloss:0.026634
## [382] train-logloss:0.026761 eval-logloss:0.026591
## [383] train-logloss:0.026716 eval-logloss:0.026547
## [384] train-logloss:0.026603 eval-logloss:0.026434
## [385] train-logloss:0.026308 eval-logloss:0.026141
## [386] train-logloss:0.026203 eval-logloss:0.026034
## [387] train-logloss:0.025911 eval-logloss:0.025745
## [388] train-logloss:0.025624 eval-logloss:0.025459
## [389] train-logloss:0.025339 eval-logloss:0.025177
## [390] train-logloss:0.025058 eval-logloss:0.024897
## [391] train-logloss:0.024780 eval-logloss:0.024621
## [392] train-logloss:0.024505 eval-logloss:0.024348
## [393] train-logloss:0.024233 eval-logloss:0.024078
## [394] train-logloss:0.024121 eval-logloss:0.023966
## [395] train-logloss:0.023853 eval-logloss:0.023700
## [396] train-logloss:0.023743 eval-logloss:0.023591
## [397] train-logloss:0.023480 eval-logloss:0.023329
## [398] train-logloss:0.023438 eval-logloss:0.023288
## [399] train-logloss:0.023394 eval-logloss:0.023244
## [400] train-logloss:0.023135 eval-logloss:0.022986
## [401] train-logloss:0.022878 eval-logloss:0.022731
## [402] train-logloss:0.022624 eval-logloss:0.022479
## [403] train-logloss:0.022522 eval-logloss:0.022378
## [404] train-logloss:0.022272 eval-logloss:0.022129
## [405] train-logloss:0.022237 eval-logloss:0.022095
## [406] train-logloss:0.021990 eval-logloss:0.021850
## [407] train-logloss:0.021746 eval-logloss:0.021608
## [408] train-logloss:0.021706 eval-logloss:0.021568
## [409] train-logloss:0.021465 eval-logloss:0.021329
## [410] train-logloss:0.021227 eval-logloss:0.021093
## [411] train-logloss:0.021094 eval-logloss:0.020955
## [412] train-logloss:0.020861 eval-logloss:0.020723
## [413] train-logloss:0.020630 eval-logloss:0.020494
## [414] train-logloss:0.020401 eval-logloss:0.020267
## [415] train-logloss:0.020176 eval-logloss:0.020043
## [416] train-logloss:0.020051 eval-logloss:0.019914
## [417] train-logloss:0.019829 eval-logloss:0.019694
## [418] train-logloss:0.019801 eval-logloss:0.019667
## [419] train-logloss:0.019582 eval-logloss:0.019450
## [420] train-logloss:0.019546 eval-logloss:0.019414
## [421] train-logloss:0.019427 eval-logloss:0.019290
## [422] train-logloss:0.019212 eval-logloss:0.019077
## [423] train-logloss:0.019000 eval-logloss:0.018867
## [424] train-logloss:0.018790 eval-logloss:0.018659
## [425] train-logloss:0.018708 eval-logloss:0.018574
## [426] train-logloss:0.018675 eval-logloss:0.018541
## [427] train-logloss:0.018469 eval-logloss:0.018337
## [428] train-logloss:0.018358 eval-logloss:0.018221
## [429] train-logloss:0.018325 eval-logloss:0.018189
## [430] train-logloss:0.018123 eval-logloss:0.017988
```

```
## [431] train-logloss:0.017924 eval-logloss:0.017790
## [432] train-logloss:0.017726 eval-logloss:0.017594
## [433] train-logloss:0.017531 eval-logloss:0.017401
## [434] train-logloss:0.017339 eval-logloss:0.017210
## [435] train-logloss:0.017308 eval-logloss:0.017179
## [436] train-logloss:0.017278 eval-logloss:0.017148
## [437] train-logloss:0.017088 eval-logloss:0.016960
## [438] train-logloss:0.016900 eval-logloss:0.016774
## [439] train-logloss:0.016801 eval-logloss:0.016670
## [440] train-logloss:0.016772 eval-logloss:0.016642
## [441] train-logloss:0.016588 eval-logloss:0.016460
## [442] train-logloss:0.016406 eval-logloss:0.016279
## [443] train-logloss:0.016226 eval-logloss:0.016101
## [444] train-logloss:0.016049 eval-logloss:0.015925
## [445] train-logloss:0.015873 eval-logloss:0.015751
## [446] train-logloss:0.015851 eval-logloss:0.015729
## [447] train-logloss:0.015678 eval-logloss:0.015557
## [448] train-logloss:0.015507 eval-logloss:0.015387
## [449] train-logloss:0.015338 eval-logloss:0.015219
## [450] train-logloss:0.015170 eval-logloss:0.015053
## [451] train-logloss:0.015124 eval-logloss:0.015006
## [452] train-logloss:0.015071 eval-logloss:0.014951
## [453] train-logloss:0.015009 eval-logloss:0.014886
## [454] train-logloss:0.014845 eval-logloss:0.014723
## [455] train-logloss:0.014683 eval-logloss:0.014563
## [456] train-logloss:0.014599 eval-logloss:0.014476
## [457] train-logloss:0.014440 eval-logloss:0.014318
## [458] train-logloss:0.014283 eval-logloss:0.014162
## [459] train-logloss:0.014128 eval-logloss:0.014008
## [460] train-logloss:0.013974 eval-logloss:0.013856
## [461] train-logloss:0.013823 eval-logloss:0.013706
## [462] train-logloss:0.013799 eval-logloss:0.013682
## [463] train-logloss:0.013776 eval-logloss:0.013659
## [464] train-logloss:0.013627 eval-logloss:0.013511
## [465] train-logloss:0.013479 eval-logloss:0.013365
## [466] train-logloss:0.013333 eval-logloss:0.013220
## [467] train-logloss:0.013189 eval-logloss:0.013077
## [468] train-logloss:0.013115 eval-logloss:0.013000
## [469] train-logloss:0.012973 eval-logloss:0.012860
## [470] train-logloss:0.012951 eval-logloss:0.012838
## [471] train-logloss:0.012812 eval-logloss:0.012699
## [472] train-logloss:0.012673 eval-logloss:0.012562
## [473] train-logloss:0.012637 eval-logloss:0.012524
## [474] train-logloss:0.012568 eval-logloss:0.012452
## [475] train-logloss:0.012499 eval-logloss:0.012381
## [476] train-logloss:0.012483 eval-logloss:0.012364
## [477] train-logloss:0.012348 eval-logloss:0.012231
## [478] train-logloss:0.012215 eval-logloss:0.012099
## [479] train-logloss:0.012083 eval-logloss:0.011969
## [480] train-logloss:0.012064 eval-logloss:0.011949
## [481] train-logloss:0.012016 eval-logloss:0.011899
## [482] train-logloss:0.011998 eval-logloss:0.011881
## [483] train-logloss:0.011868 eval-logloss:0.011753
## [484] train-logloss:0.011741 eval-logloss:0.011626
```

```

## [485] train-logloss:0.011614 eval-logloss:0.011501
## [486] train-logloss:0.011602 eval-logloss:0.011489
## [487] train-logloss:0.011540 eval-logloss:0.011425
## [488] train-logloss:0.011416 eval-logloss:0.011303
## [489] train-logloss:0.011294 eval-logloss:0.011181
## [490] train-logloss:0.011234 eval-logloss:0.011120
## [491] train-logloss:0.011114 eval-logloss:0.011001
## [492] train-logloss:0.011097 eval-logloss:0.010984
## [493] train-logloss:0.011085 eval-logloss:0.010972
## [494] train-logloss:0.010966 eval-logloss:0.010854
## [495] train-logloss:0.010848 eval-logloss:0.010738
## [496] train-logloss:0.010832 eval-logloss:0.010722
## [497] train-logloss:0.010818 eval-logloss:0.010708
## [498] train-logloss:0.010702 eval-logloss:0.010593
## [499] train-logloss:0.010587 eval-logloss:0.010480
## [500] train-logloss:0.010532 eval-logloss:0.010425
## [501] train-logloss:0.010478 eval-logloss:0.010370
## [502] train-logloss:0.010366 eval-logloss:0.010259
## [503] train-logloss:0.010255 eval-logloss:0.010150
## [504] train-logloss:0.010219 eval-logloss:0.010113
## [505] train-logloss:0.010110 eval-logloss:0.010005
## [506] train-logloss:0.010095 eval-logloss:0.009991
## [507] train-logloss:0.010043 eval-logloss:0.009940
## [508] train-logloss:0.010017 eval-logloss:0.009914
## [509] train-logloss:0.009910 eval-logloss:0.009808
## [510] train-logloss:0.009804 eval-logloss:0.009703
## [511] train-logloss:0.009700 eval-logloss:0.009600
## [512] train-logloss:0.009674 eval-logloss:0.009575
## [513] train-logloss:0.009641 eval-logloss:0.009543
## [514] train-logloss:0.009538 eval-logloss:0.009441
## [515] train-logloss:0.009437 eval-logloss:0.009340
## [516] train-logloss:0.009336 eval-logloss:0.009241
## [517] train-logloss:0.009237 eval-logloss:0.009143
## [518] train-logloss:0.009139 eval-logloss:0.009046
## [519] train-logloss:0.009042 eval-logloss:0.008950
## [520] train-logloss:0.008997 eval-logloss:0.008905
## [521] train-logloss:0.008902 eval-logloss:0.008811
## [522] train-logloss:0.008894 eval-logloss:0.008803
## [523] train-logloss:0.008799 eval-logloss:0.008710
## [524] train-logloss:0.008706 eval-logloss:0.008618
## [525] train-logloss:0.008694 eval-logloss:0.008606
## [526] train-logloss:0.008602 eval-logloss:0.008515
## [527] train-logloss:0.008560 eval-logloss:0.008473
## [528] train-logloss:0.008470 eval-logloss:0.008384
## [529] train-logloss:0.008429 eval-logloss:0.008343
## [530] train-logloss:0.008389 eval-logloss:0.008303
## [531] train-logloss:0.008300 eval-logloss:0.008216
## [532] train-logloss:0.008274 eval-logloss:0.008189
## [533] train-logloss:0.008186 eval-logloss:0.008102
## [534] train-logloss:0.008160 eval-logloss:0.008076
## [535] train-logloss:0.008074 eval-logloss:0.007991
## [536] train-logloss:0.007989 eval-logloss:0.007906
## [537] train-logloss:0.007978 eval-logloss:0.007895
## [538] train-logloss:0.007894 eval-logloss:0.007812

```

```
## [539] train-logloss:0.007810 eval-logloss:0.007729
## [540] train-logloss:0.007800 eval-logloss:0.007719
## [541] train-logloss:0.007718 eval-logloss:0.007638
## [542] train-logloss:0.007682 eval-logloss:0.007602
## [543] train-logloss:0.007601 eval-logloss:0.007522
## [544] train-logloss:0.007578 eval-logloss:0.007499
## [545] train-logloss:0.007543 eval-logloss:0.007463
## [546] train-logloss:0.007464 eval-logloss:0.007384
## [547] train-logloss:0.007442 eval-logloss:0.007362
## [548] train-logloss:0.007431 eval-logloss:0.007352
## [549] train-logloss:0.007413 eval-logloss:0.007334
## [550] train-logloss:0.007335 eval-logloss:0.007256
## [551] train-logloss:0.007258 eval-logloss:0.007180
## [552] train-logloss:0.007182 eval-logloss:0.007105
## [553] train-logloss:0.007107 eval-logloss:0.007030
## [554] train-logloss:0.007076 eval-logloss:0.007000
## [555] train-logloss:0.007046 eval-logloss:0.006971
## [556] train-logloss:0.006972 eval-logloss:0.006898
## [557] train-logloss:0.006899 eval-logloss:0.006826
## [558] train-logloss:0.006826 eval-logloss:0.006754
## [559] train-logloss:0.006755 eval-logloss:0.006684
## [560] train-logloss:0.006726 eval-logloss:0.006656
## [561] train-logloss:0.006698 eval-logloss:0.006629
## [562] train-logloss:0.006689 eval-logloss:0.006620
## [563] train-logloss:0.006619 eval-logloss:0.006551
## [564] train-logloss:0.006591 eval-logloss:0.006521
## [565] train-logloss:0.006563 eval-logloss:0.006495
## [566] train-logloss:0.006558 eval-logloss:0.006490
## [567] train-logloss:0.006531 eval-logloss:0.006465
## [568] train-logloss:0.006463 eval-logloss:0.006397
## [569] train-logloss:0.006396 eval-logloss:0.006330
## [570] train-logloss:0.006329 eval-logloss:0.006264
## [571] train-logloss:0.006263 eval-logloss:0.006199
## [572] train-logloss:0.006256 eval-logloss:0.006192
## [573] train-logloss:0.006190 eval-logloss:0.006127
## [574] train-logloss:0.006126 eval-logloss:0.006063
## [575] train-logloss:0.006062 eval-logloss:0.006000
## [576] train-logloss:0.006038 eval-logloss:0.005977
## [577] train-logloss:0.006014 eval-logloss:0.005953
## [578] train-logloss:0.005951 eval-logloss:0.005891
## [579] train-logloss:0.005889 eval-logloss:0.005830
## [580] train-logloss:0.005866 eval-logloss:0.005807
## [581] train-logloss:0.005806 eval-logloss:0.005747
## [582] train-logloss:0.005788 eval-logloss:0.005729
## [583] train-logloss:0.005781 eval-logloss:0.005721
## [584] train-logloss:0.005721 eval-logloss:0.005662
## [585] train-logloss:0.005662 eval-logloss:0.005603
## [586] train-logloss:0.005640 eval-logloss:0.005582
## [587] train-logloss:0.005581 eval-logloss:0.005524
## [588] train-logloss:0.005523 eval-logloss:0.005467
## [589] train-logloss:0.005466 eval-logloss:0.005410
## [590] train-logloss:0.005410 eval-logloss:0.005354
## [591] train-logloss:0.005354 eval-logloss:0.005298
## [592] train-logloss:0.005298 eval-logloss:0.005244
```

```
## [593] train-logloss:0.005243 eval-logloss:0.005189
## [594] train-logloss:0.005189 eval-logloss:0.005136
## [595] train-logloss:0.005170 eval-logloss:0.005117
## [596] train-logloss:0.005166 eval-logloss:0.005113
## [597] train-logloss:0.005162 eval-logloss:0.005109
## [598] train-logloss:0.005142 eval-logloss:0.005090
## [599] train-logloss:0.005122 eval-logloss:0.005069
## [600] train-logloss:0.005069 eval-logloss:0.005017
## [601] train-logloss:0.005063 eval-logloss:0.005011
## [602] train-logloss:0.005011 eval-logloss:0.004960
## [603] train-logloss:0.004959 eval-logloss:0.004908
## [604] train-logloss:0.004956 eval-logloss:0.004906
## [605] train-logloss:0.004905 eval-logloss:0.004855
## [606] train-logloss:0.004854 eval-logloss:0.004805
## [607] train-logloss:0.004849 eval-logloss:0.004799
## [608] train-logloss:0.004843 eval-logloss:0.004793
## [609] train-logloss:0.004793 eval-logloss:0.004744
## [610] train-logloss:0.004787 eval-logloss:0.004738
## [611] train-logloss:0.004738 eval-logloss:0.004689
## [612] train-logloss:0.004721 eval-logloss:0.004672
## [613] train-logloss:0.004716 eval-logloss:0.004668
## [614] train-logloss:0.004698 eval-logloss:0.004649
## [615] train-logloss:0.004649 eval-logloss:0.004601
## [616] train-logloss:0.004602 eval-logloss:0.004554
## [617] train-logloss:0.004585 eval-logloss:0.004538
## [618] train-logloss:0.004538 eval-logloss:0.004491
## [619] train-logloss:0.004491 eval-logloss:0.004445
## [620] train-logloss:0.004445 eval-logloss:0.004399
## [621] train-logloss:0.004430 eval-logloss:0.004384
## [622] train-logloss:0.004425 eval-logloss:0.004379
## [623] train-logloss:0.004380 eval-logloss:0.004335
## [624] train-logloss:0.004335 eval-logloss:0.004290
## [625] train-logloss:0.004290 eval-logloss:0.004246
## [626] train-logloss:0.004246 eval-logloss:0.004202
## [627] train-logloss:0.004203 eval-logloss:0.004159
## [628] train-logloss:0.004160 eval-logloss:0.004117
## [629] train-logloss:0.004157 eval-logloss:0.004115
## [630] train-logloss:0.004115 eval-logloss:0.004073
## [631] train-logloss:0.004073 eval-logloss:0.004031
## [632] train-logloss:0.004031 eval-logloss:0.003990
## [633] train-logloss:0.004027 eval-logloss:0.003986
## [634] train-logloss:0.004013 eval-logloss:0.003972
## [635] train-logloss:0.003972 eval-logloss:0.003932
## [636] train-logloss:0.003932 eval-logloss:0.003891
## [637] train-logloss:0.003927 eval-logloss:0.003887
## [638] train-logloss:0.003914 eval-logloss:0.003874
## [639] train-logloss:0.003874 eval-logloss:0.003834
## [640] train-logloss:0.003834 eval-logloss:0.003795
## [641] train-logloss:0.003830 eval-logloss:0.003791
## [642] train-logloss:0.003826 eval-logloss:0.003787
## [643] train-logloss:0.003787 eval-logloss:0.003748
## [644] train-logloss:0.003749 eval-logloss:0.003710
## [645] train-logloss:0.003710 eval-logloss:0.003672
## [646] train-logloss:0.003697 eval-logloss:0.003658
```

```
## [647] train-logloss:0.003694 eval-logloss:0.003656
## [648] train-logloss:0.003682 eval-logloss:0.003644
## [649] train-logloss:0.003645 eval-logloss:0.003607
## [650] train-logloss:0.003633 eval-logloss:0.003595
## [651] train-logloss:0.003596 eval-logloss:0.003559
## [652] train-logloss:0.003559 eval-logloss:0.003522
## [653] train-logloss:0.003523 eval-logloss:0.003487
## [654] train-logloss:0.003487 eval-logloss:0.003451
## [655] train-logloss:0.003484 eval-logloss:0.003448
## [656] train-logloss:0.003481 eval-logloss:0.003446
## [657] train-logloss:0.003478 eval-logloss:0.003442
## [658] train-logloss:0.003443 eval-logloss:0.003407
## [659] train-logloss:0.003441 eval-logloss:0.003405
## [660] train-logloss:0.003432 eval-logloss:0.003396
## [661] train-logloss:0.003397 eval-logloss:0.003361
## [662] train-logloss:0.003395 eval-logloss:0.003360
## [663] train-logloss:0.003392 eval-logloss:0.003356
## [664] train-logloss:0.003357 eval-logloss:0.003322
## [665] train-logloss:0.003323 eval-logloss:0.003289
## [666] train-logloss:0.003320 eval-logloss:0.003285
## [667] train-logloss:0.003286 eval-logloss:0.003252
## [668] train-logloss:0.003275 eval-logloss:0.003240
## [669] train-logloss:0.003242 eval-logloss:0.003207
## [670] train-logloss:0.003239 eval-logloss:0.003205
## [671] train-logloss:0.003206 eval-logloss:0.003172
## [672] train-logloss:0.003204 eval-logloss:0.003170
## [673] train-logloss:0.003172 eval-logloss:0.003138
## [674] train-logloss:0.003162 eval-logloss:0.003128
## [675] train-logloss:0.003130 eval-logloss:0.003097
## [676] train-logloss:0.003127 eval-logloss:0.003094
## [677] train-logloss:0.003096 eval-logloss:0.003063
## [678] train-logloss:0.003064 eval-logloss:0.003032
## [679] train-logloss:0.003033 eval-logloss:0.003001
## [680] train-logloss:0.003002 eval-logloss:0.002971
## [681] train-logloss:0.002972 eval-logloss:0.002941
## [682] train-logloss:0.002965 eval-logloss:0.002933
## [683] train-logloss:0.002962 eval-logloss:0.002931
## [684] train-logloss:0.002932 eval-logloss:0.002901
## [685] train-logloss:0.002903 eval-logloss:0.002872
## [686] train-logloss:0.002897 eval-logloss:0.002866
## [687] train-logloss:0.002867 eval-logloss:0.002837
## [688] train-logloss:0.002860 eval-logloss:0.002829
## [689] train-logloss:0.002831 eval-logloss:0.002801
## [690] train-logloss:0.002803 eval-logloss:0.002773
## [691] train-logloss:0.002797 eval-logloss:0.002767
## [692] train-logloss:0.002795 eval-logloss:0.002764
## [693] train-logloss:0.002767 eval-logloss:0.002737
## [694] train-logloss:0.002739 eval-logloss:0.002709
## [695] train-logloss:0.002711 eval-logloss:0.002682
## [696] train-logloss:0.002684 eval-logloss:0.002655
## [697] train-logloss:0.002657 eval-logloss:0.002628
## [698] train-logloss:0.002630 eval-logloss:0.002601
## [699] train-logloss:0.002621 eval-logloss:0.002593
## [700] train-logloss:0.002619 eval-logloss:0.002591
```

```
## [701] train-logloss:0.002618 eval-logloss:0.002589
## [702] train-logloss:0.002613 eval-logloss:0.002584
## [703] train-logloss:0.002586 eval-logloss:0.002558
## [704] train-logloss:0.002579 eval-logloss:0.002551
## [705] train-logloss:0.002577 eval-logloss:0.002548
## [706] train-logloss:0.002551 eval-logloss:0.002523
## [707] train-logloss:0.002526 eval-logloss:0.002497
## [708] train-logloss:0.002500 eval-logloss:0.002472
## [709] train-logloss:0.002475 eval-logloss:0.002447
## [710] train-logloss:0.002450 eval-logloss:0.002423
## [711] train-logloss:0.002426 eval-logloss:0.002399
## [712] train-logloss:0.002424 eval-logloss:0.002396
## [713] train-logloss:0.002418 eval-logloss:0.002391
## [714] train-logloss:0.002410 eval-logloss:0.002383
## [715] train-logloss:0.002386 eval-logloss:0.002359
## [716] train-logloss:0.002362 eval-logloss:0.002335
## [717] train-logloss:0.002356 eval-logloss:0.002329
## [718] train-logloss:0.002332 eval-logloss:0.002306
## [719] train-logloss:0.002309 eval-logloss:0.002283
## [720] train-logloss:0.002286 eval-logloss:0.002260
## [721] train-logloss:0.002280 eval-logloss:0.002254
## [722] train-logloss:0.002273 eval-logloss:0.002247
## [723] train-logloss:0.002250 eval-logloss:0.002225
## [724] train-logloss:0.002228 eval-logloss:0.002202
## [725] train-logloss:0.002224 eval-logloss:0.002199
## [726] train-logloss:0.002202 eval-logloss:0.002177
## [727] train-logloss:0.002180 eval-logloss:0.002155
## [728] train-logloss:0.002174 eval-logloss:0.002149
## [729] train-logloss:0.002153 eval-logloss:0.002128
## [730] train-logloss:0.002131 eval-logloss:0.002107
## [731] train-logloss:0.002110 eval-logloss:0.002086
## [732] train-logloss:0.002104 eval-logloss:0.002080
## [733] train-logloss:0.002098 eval-logloss:0.002075
## [734] train-logloss:0.002077 eval-logloss:0.002054
## [735] train-logloss:0.002057 eval-logloss:0.002033
## [736] train-logloss:0.002036 eval-logloss:0.002013
## [737] train-logloss:0.002016 eval-logloss:0.001993
## [738] train-logloss:0.001996 eval-logloss:0.001973
## [739] train-logloss:0.001994 eval-logloss:0.001972
## [740] train-logloss:0.001974 eval-logloss:0.001952
## [741] train-logloss:0.001971 eval-logloss:0.001949
## [742] train-logloss:0.001951 eval-logloss:0.001929
## [743] train-logloss:0.001950 eval-logloss:0.001928
## [744] train-logloss:0.001931 eval-logloss:0.001909
## [745] train-logloss:0.001925 eval-logloss:0.001904
## [746] train-logloss:0.001906 eval-logloss:0.001885
## [747] train-logloss:0.001887 eval-logloss:0.001866
## [748] train-logloss:0.001869 eval-logloss:0.001847
## [749] train-logloss:0.001867 eval-logloss:0.001846
## [750] train-logloss:0.001866 eval-logloss:0.001845
## [751] train-logloss:0.001861 eval-logloss:0.001840
## [752] train-logloss:0.001842 eval-logloss:0.001822
## [753] train-logloss:0.001824 eval-logloss:0.001804
## [754] train-logloss:0.001806 eval-logloss:0.001786
```

```
## [755] train-logloss:0.001805 eval-logloss:0.001785
## [756] train-logloss:0.001802 eval-logloss:0.001782
## [757] train-logloss:0.001784 eval-logloss:0.001764
## [758] train-logloss:0.001783 eval-logloss:0.001763
## [759] train-logloss:0.001765 eval-logloss:0.001746
## [760] train-logloss:0.001748 eval-logloss:0.001729
## [761] train-logloss:0.001731 eval-logloss:0.001711
## [762] train-logloss:0.001713 eval-logloss:0.001694
## [763] train-logloss:0.001711 eval-logloss:0.001692
## [764] train-logloss:0.001710 eval-logloss:0.001691
## [765] train-logloss:0.001693 eval-logloss:0.001674
## [766] train-logloss:0.001692 eval-logloss:0.001674
## [767] train-logloss:0.001675 eval-logloss:0.001657
## [768] train-logloss:0.001674 eval-logloss:0.001656
## [769] train-logloss:0.001671 eval-logloss:0.001653
## [770] train-logloss:0.001667 eval-logloss:0.001649
## [771] train-logloss:0.001651 eval-logloss:0.001633
## [772] train-logloss:0.001635 eval-logloss:0.001617
## [773] train-logloss:0.001618 eval-logloss:0.001601
## [774] train-logloss:0.001602 eval-logloss:0.001585
## [775] train-logloss:0.001598 eval-logloss:0.001581
## [776] train-logloss:0.001595 eval-logloss:0.001578
## [777] train-logloss:0.001592 eval-logloss:0.001575
## [778] train-logloss:0.001576 eval-logloss:0.001559
## [779] train-logloss:0.001576 eval-logloss:0.001559
## [780] train-logloss:0.001560 eval-logloss:0.001543
## [781] train-logloss:0.001556 eval-logloss:0.001540
## [782] train-logloss:0.001541 eval-logloss:0.001524
## [783] train-logloss:0.001540 eval-logloss:0.001524
## [784] train-logloss:0.001525 eval-logloss:0.001509
## [785] train-logloss:0.001510 eval-logloss:0.001494
## [786] train-logloss:0.001509 eval-logloss:0.001493
## [787] train-logloss:0.001494 eval-logloss:0.001478
## [788] train-logloss:0.001479 eval-logloss:0.001464
## [789] train-logloss:0.001465 eval-logloss:0.001449
## [790] train-logloss:0.001464 eval-logloss:0.001449
## [791] train-logloss:0.001450 eval-logloss:0.001435
## [792] train-logloss:0.001436 eval-logloss:0.001421
## [793] train-logloss:0.001435 eval-logloss:0.001420
## [794] train-logloss:0.001421 eval-logloss:0.001406
## [795] train-logloss:0.001407 eval-logloss:0.001392
## [796] train-logloss:0.001393 eval-logloss:0.001378
## [797] train-logloss:0.001379 eval-logloss:0.001365
## [798] train-logloss:0.001366 eval-logloss:0.001352
## [799] train-logloss:0.001352 eval-logloss:0.001338
## [800] train-logloss:0.001339 eval-logloss:0.001325
## [801] train-logloss:0.001336 eval-logloss:0.001322
## [802] train-logloss:0.001335 eval-logloss:0.001322
## [803] train-logloss:0.001322 eval-logloss:0.001309
## [804] train-logloss:0.001309 eval-logloss:0.001296
## [805] train-logloss:0.001296 eval-logloss:0.001283
## [806] train-logloss:0.001293 eval-logloss:0.001280
## [807] train-logloss:0.001281 eval-logloss:0.001268
## [808] train-logloss:0.001268 eval-logloss:0.001255
```

```
## [809] train-logloss:0.001256 eval-logloss:0.001243
## [810] train-logloss:0.001255 eval-logloss:0.001243
## [811] train-logloss:0.001243 eval-logloss:0.001231
## [812] train-logloss:0.001241 eval-logloss:0.001228
## [813] train-logloss:0.001229 eval-logloss:0.001216
## [814] train-logloss:0.001228 eval-logloss:0.001216
## [815] train-logloss:0.001216 eval-logloss:0.001204
## [816] train-logloss:0.001204 eval-logloss:0.001192
## [817] train-logloss:0.001202 eval-logloss:0.001190
## [818] train-logloss:0.001191 eval-logloss:0.001179
## [819] train-logloss:0.001189 eval-logloss:0.001177
## [820] train-logloss:0.001177 eval-logloss:0.001165
## [821] train-logloss:0.001166 eval-logloss:0.001154
## [822] train-logloss:0.001154 eval-logloss:0.001143
## [823] train-logloss:0.001143 eval-logloss:0.001132
## [824] train-logloss:0.001132 eval-logloss:0.001121
## [825] train-logloss:0.001129 eval-logloss:0.001118
## [826] train-logloss:0.001128 eval-logloss:0.001117
## [827] train-logloss:0.001125 eval-logloss:0.001114
## [828] train-logloss:0.001123 eval-logloss:0.001112
## [829] train-logloss:0.001122 eval-logloss:0.001111
## [830] train-logloss:0.001119 eval-logloss:0.001109
## [831] train-logloss:0.001108 eval-logloss:0.001098
## [832] train-logloss:0.001098 eval-logloss:0.001087
## [833] train-logloss:0.001087 eval-logloss:0.001077
## [834] train-logloss:0.001076 eval-logloss:0.001066
## [835] train-logloss:0.001066 eval-logloss:0.001056
## [836] train-logloss:0.001065 eval-logloss:0.001055
## [837] train-logloss:0.001065 eval-logloss:0.001055
## [838] train-logloss:0.001062 eval-logloss:0.001053
## [839] train-logloss:0.001061 eval-logloss:0.001051
## [840] train-logloss:0.001059 eval-logloss:0.001049
## [841] train-logloss:0.001049 eval-logloss:0.001039
## [842] train-logloss:0.001039 eval-logloss:0.001029
## [843] train-logloss:0.001029 eval-logloss:0.001019
## [844] train-logloss:0.001019 eval-logloss:0.001009
## [845] train-logloss:0.001018 eval-logloss:0.001009
## [846] train-logloss:0.001008 eval-logloss:0.000999
## [847] train-logloss:0.001006 eval-logloss:0.000997
## [848] train-logloss:0.000997 eval-logloss:0.000988
## [849] train-logloss:0.000996 eval-logloss:0.000987
## [850] train-logloss:0.000987 eval-logloss:0.000978
## [851] train-logloss:0.000977 eval-logloss:0.000968
## [852] train-logloss:0.000977 eval-logloss:0.000968
## [853] train-logloss:0.000967 eval-logloss:0.000959
## [854] train-logloss:0.000958 eval-logloss:0.000949
## [855] train-logloss:0.000957 eval-logloss:0.000949
## [856] train-logloss:0.000948 eval-logloss:0.000940
## [857] train-logloss:0.000939 eval-logloss:0.000931
## [858] train-logloss:0.000938 eval-logloss:0.000930
## [859] train-logloss:0.000936 eval-logloss:0.000928
## [860] train-logloss:0.000935 eval-logloss:0.000927
## [861] train-logloss:0.000935 eval-logloss:0.000927
## [862] train-logloss:0.000933 eval-logloss:0.000925
```

```
## [863] train-logloss:0.000924 eval-logloss:0.000916
## [864] train-logloss:0.000916 eval-logloss:0.000908
## [865] train-logloss:0.000907 eval-logloss:0.000899
## [866] train-logloss:0.000906 eval-logloss:0.000898
## [867] train-logloss:0.000897 eval-logloss:0.000889
## [868] train-logloss:0.000896 eval-logloss:0.000888
## [869] train-logloss:0.000887 eval-logloss:0.000879
## [870] train-logloss:0.000878 eval-logloss:0.000871
## [871] train-logloss:0.000877 eval-logloss:0.000869
## [872] train-logloss:0.000869 eval-logloss:0.000861
## [873] train-logloss:0.000867 eval-logloss:0.000859
## [874] train-logloss:0.000858 eval-logloss:0.000851
## [875] train-logloss:0.000850 eval-logloss:0.000843
## [876] train-logloss:0.000842 eval-logloss:0.000835
## [877] train-logloss:0.000834 eval-logloss:0.000827
## [878] train-logloss:0.000826 eval-logloss:0.000819
## [879] train-logloss:0.000825 eval-logloss:0.000818
## [880] train-logloss:0.000825 eval-logloss:0.000818
## [881] train-logloss:0.000825 eval-logloss:0.000818
## [882] train-logloss:0.000823 eval-logloss:0.000816
## [883] train-logloss:0.000815 eval-logloss:0.000808
## [884] train-logloss:0.000813 eval-logloss:0.000806
## [885] train-logloss:0.000812 eval-logloss:0.000805
## [886] train-logloss:0.000804 eval-logloss:0.000798
## [887] train-logloss:0.000797 eval-logloss:0.000790
## [888] train-logloss:0.000789 eval-logloss:0.000782
## [889] train-logloss:0.000789 eval-logloss:0.000782
## [890] train-logloss:0.000781 eval-logloss:0.000775
## [891] train-logloss:0.000781 eval-logloss:0.000775
## [892] train-logloss:0.000774 eval-logloss:0.000767
## [893] train-logloss:0.000773 eval-logloss:0.000767
## [894] train-logloss:0.000766 eval-logloss:0.000760
## [895] train-logloss:0.000758 eval-logloss:0.000752
## [896] train-logloss:0.000758 eval-logloss:0.000752
## [897] train-logloss:0.000757 eval-logloss:0.000751
## [898] train-logloss:0.000750 eval-logloss:0.000744
## [899] train-logloss:0.000749 eval-logloss:0.000743
## [900] train-logloss:0.000742 eval-logloss:0.000736
## [901] train-logloss:0.000735 eval-logloss:0.000729
## [902] train-logloss:0.000734 eval-logloss:0.000728
## [903] train-logloss:0.000734 eval-logloss:0.000728
## [904] train-logloss:0.000727 eval-logloss:0.000721
## [905] train-logloss:0.000725 eval-logloss:0.000719
## [906] train-logloss:0.000718 eval-logloss:0.000713
## [907] train-logloss:0.000711 eval-logloss:0.000706
## [908] train-logloss:0.000710 eval-logloss:0.000705
## [909] train-logloss:0.000703 eval-logloss:0.000698
## [910] train-logloss:0.000702 eval-logloss:0.000697
## [911] train-logloss:0.000695 eval-logloss:0.000690
## [912] train-logloss:0.000694 eval-logloss:0.000689
## [913] train-logloss:0.000693 eval-logloss:0.000688
## [914] train-logloss:0.000687 eval-logloss:0.000682
## [915] train-logloss:0.000686 eval-logloss:0.000681
## [916] train-logloss:0.000680 eval-logloss:0.000675
```

```
## [917] train-logloss:0.000673 eval-logloss:0.000668
## [918] train-logloss:0.000673 eval-logloss:0.000668
## [919] train-logloss:0.000673 eval-logloss:0.000668
## [920] train-logloss:0.000667 eval-logloss:0.000662
## [921] train-logloss:0.000660 eval-logloss:0.000656
## [922] train-logloss:0.000654 eval-logloss:0.000649
## [923] train-logloss:0.000648 eval-logloss:0.000643
## [924] train-logloss:0.000642 eval-logloss:0.000637
## [925] train-logloss:0.000636 eval-logloss:0.000631
## [926] train-logloss:0.000636 eval-logloss:0.000631
## [927] train-logloss:0.000630 eval-logloss:0.000625
## [928] train-logloss:0.000629 eval-logloss:0.000625
## [929] train-logloss:0.000623 eval-logloss:0.000619
## [930] train-logloss:0.000623 eval-logloss:0.000619
## [931] train-logloss:0.000617 eval-logloss:0.000613
## [932] train-logloss:0.000611 eval-logloss:0.000607
## [933] train-logloss:0.000606 eval-logloss:0.000602
## [934] train-logloss:0.000600 eval-logloss:0.000596
## [935] train-logloss:0.000600 eval-logloss:0.000596
## [936] train-logloss:0.000594 eval-logloss:0.000590
## [937] train-logloss:0.000588 eval-logloss:0.000584
## [938] train-logloss:0.000583 eval-logloss:0.000579
## [939] train-logloss:0.000583 eval-logloss:0.000579
## [940] train-logloss:0.000582 eval-logloss:0.000579
## [941] train-logloss:0.000577 eval-logloss:0.000573
## [942] train-logloss:0.000576 eval-logloss:0.000572
## [943] train-logloss:0.000571 eval-logloss:0.000567
## [944] train-logloss:0.000571 eval-logloss:0.000567
## [945] train-logloss:0.000565 eval-logloss:0.000561
## [946] train-logloss:0.000564 eval-logloss:0.000561
## [947] train-logloss:0.000559 eval-logloss:0.000555
## [948] train-logloss:0.000558 eval-logloss:0.000554
## [949] train-logloss:0.000553 eval-logloss:0.000549
## [950] train-logloss:0.000548 eval-logloss:0.000544
## [951] train-logloss:0.000543 eval-logloss:0.000539
## [952] train-logloss:0.000538 eval-logloss:0.000534
## [953] train-logloss:0.000537 eval-logloss:0.000534
## [954] train-logloss:0.000537 eval-logloss:0.000533
## [955] train-logloss:0.000532 eval-logloss:0.000528
## [956] train-logloss:0.000531 eval-logloss:0.000528
## [957] train-logloss:0.000527 eval-logloss:0.000523
## [958] train-logloss:0.000522 eval-logloss:0.000518
## [959] train-logloss:0.000517 eval-logloss:0.000514
## [960] train-logloss:0.000512 eval-logloss:0.000509
## [961] train-logloss:0.000511 eval-logloss:0.000508
## [962] train-logloss:0.000506 eval-logloss:0.000503
## [963] train-logloss:0.000502 eval-logloss:0.000498
## [964] train-logloss:0.000501 eval-logloss:0.000497
## [965] train-logloss:0.000500 eval-logloss:0.000497
## [966] train-logloss:0.000499 eval-logloss:0.000497
## [967] train-logloss:0.000495 eval-logloss:0.000492
## [968] train-logloss:0.000490 eval-logloss:0.000487
## [969] train-logloss:0.000486 eval-logloss:0.000483
## [970] train-logloss:0.000481 eval-logloss:0.000478
```

```

## [971] train-logloss:0.000477 eval-logloss:0.000474
## [972] train-logloss:0.000473 eval-logloss:0.000470
## [973] train-logloss:0.000468 eval-logloss:0.000465
## [974] train-logloss:0.000468 eval-logloss:0.000465
## [975] train-logloss:0.000463 eval-logloss:0.000461
## [976] train-logloss:0.000459 eval-logloss:0.000456
## [977] train-logloss:0.000455 eval-logloss:0.000452
## [978] train-logloss:0.000451 eval-logloss:0.000448
## [979] train-logloss:0.000447 eval-logloss:0.000444
## [980] train-logloss:0.000446 eval-logloss:0.000444
## [981] train-logloss:0.000442 eval-logloss:0.000440
## [982] train-logloss:0.000441 eval-logloss:0.000439
## [983] train-logloss:0.000437 eval-logloss:0.000435
## [984] train-logloss:0.000436 eval-logloss:0.000434
## [985] train-logloss:0.000436 eval-logloss:0.000433
## [986] train-logloss:0.000432 eval-logloss:0.000429
## [987] train-logloss:0.000431 eval-logloss:0.000428
## [988] train-logloss:0.000427 eval-logloss:0.000425
## [989] train-logloss:0.000423 eval-logloss:0.000421
## [990] train-logloss:0.000419 eval-logloss:0.000417
## [991] train-logloss:0.000419 eval-logloss:0.000417
## [992] train-logloss:0.000419 eval-logloss:0.000417
## [993] train-logloss:0.000415 eval-logloss:0.000413
## [994] train-logloss:0.000415 eval-logloss:0.000413
## [995] train-logloss:0.000415 eval-logloss:0.000413
## [996] train-logloss:0.000411 eval-logloss:0.000409
## [997] train-logloss:0.000411 eval-logloss:0.000409
## [998] train-logloss:0.000407 eval-logloss:0.000405
## [999] train-logloss:0.000407 eval-logloss:0.000405
## [1000] train-logloss:0.000403 eval-logloss:0.000401
## [1] train-logloss:0.683199 eval-logloss:0.683199
## Multiple eval metrics are present. Will use eval_logloss for early stopping.
## Will train until eval_logloss hasn't improved in 10 rounds.
##
## [2] train-logloss:0.673449 eval-logloss:0.673449
## [3] train-logloss:0.663889 eval-logloss:0.663891
## [4] train-logloss:0.654516 eval-logloss:0.654518
## [5] train-logloss:0.645556 eval-logloss:0.645556
## [6] train-logloss:0.636733 eval-logloss:0.636728
## [7] train-logloss:0.628064 eval-logloss:0.628055
## [8] train-logloss:0.619369 eval-logloss:0.619360
## [9] train-logloss:0.614719 eval-logloss:0.614706
## [10] train-logloss:0.606271 eval-logloss:0.606259
## [11] train-logloss:0.597978 eval-logloss:0.597966
## [12] train-logloss:0.589837 eval-logloss:0.589826
## [13] train-logloss:0.581842 eval-logloss:0.581832
## [14] train-logloss:0.574205 eval-logloss:0.574196
## [15] train-logloss:0.567712 eval-logloss:0.567709
## [16] train-logloss:0.560109 eval-logloss:0.560107
## [17] train-logloss:0.552639 eval-logloss:0.552638
## [18] train-logloss:0.545299 eval-logloss:0.545299
## [19] train-logloss:0.538086 eval-logloss:0.538086
## [20] train-logloss:0.530996 eval-logloss:0.530997
## [21] train-logloss:0.524162 eval-logloss:0.524156

```

```
## [22] train-logloss:0.518410 eval-logloss:0.518412
## [23] train-logloss:0.511651 eval-logloss:0.511653
## [24] train-logloss:0.505190 eval-logloss:0.505191
## [25] train-logloss:0.498650 eval-logloss:0.498651
## [26] train-logloss:0.492218 eval-logloss:0.492220
## [27] train-logloss:0.485892 eval-logloss:0.485894
## [28] train-logloss:0.479841 eval-logloss:0.479842
## [29] train-logloss:0.473715 eval-logloss:0.473717
## [30] train-logloss:0.467687 eval-logloss:0.467689
## [31] train-logloss:0.461934 eval-logloss:0.461937
## [32] train-logloss:0.456217 eval-logloss:0.456214
## [33] train-logloss:0.450625 eval-logloss:0.450619
## [34] train-logloss:0.445072 eval-logloss:0.445065
## [35] train-logloss:0.439495 eval-logloss:0.439488
## [36] train-logloss:0.434187 eval-logloss:0.434182
## [37] train-logloss:0.428778 eval-logloss:0.428773
## [38] train-logloss:0.423559 eval-logloss:0.423554
## [39] train-logloss:0.418312 eval-logloss:0.418307
## [40] train-logloss:0.413336 eval-logloss:0.413330
## [41] train-logloss:0.408359 eval-logloss:0.408350
## [42] train-logloss:0.403341 eval-logloss:0.403333
## [43] train-logloss:0.398398 eval-logloss:0.398391
## [44] train-logloss:0.393528 eval-logloss:0.393521
## [45] train-logloss:0.388730 eval-logloss:0.388724
## [46] train-logloss:0.384104 eval-logloss:0.384097
## [47] train-logloss:0.379445 eval-logloss:0.379438
## [48] train-logloss:0.374854 eval-logloss:0.374848
## [49] train-logloss:0.370329 eval-logloss:0.370324
## [50] train-logloss:0.365870 eval-logloss:0.365865
## [51] train-logloss:0.362217 eval-logloss:0.362222
## [52] train-logloss:0.358030 eval-logloss:0.358037
## [53] train-logloss:0.355683 eval-logloss:0.355695
## [54] train-logloss:0.351535 eval-logloss:0.351544
## [55] train-logloss:0.347343 eval-logloss:0.347352
## [56] train-logloss:0.343312 eval-logloss:0.343318
## [57] train-logloss:0.341101 eval-logloss:0.341108
## [58] train-logloss:0.338922 eval-logloss:0.338933
## [59] train-logloss:0.335036 eval-logloss:0.335046
## [60] train-logloss:0.331076 eval-logloss:0.331085
## [61] train-logloss:0.327170 eval-logloss:0.327180
## [62] train-logloss:0.323407 eval-logloss:0.323412
## [63] train-logloss:0.319696 eval-logloss:0.319698
## [64] train-logloss:0.315947 eval-logloss:0.315949
## [65] train-logloss:0.312249 eval-logloss:0.312251
## [66] train-logloss:0.308689 eval-logloss:0.308687
## [67] train-logloss:0.305718 eval-logloss:0.305733
## [68] train-logloss:0.302790 eval-logloss:0.302821
## [69] train-logloss:0.299358 eval-logloss:0.299384
## [70] train-logloss:0.295884 eval-logloss:0.295910
## [71] train-logloss:0.292456 eval-logloss:0.292483
## [72] train-logloss:0.289075 eval-logloss:0.289102
## [73] train-logloss:0.285739 eval-logloss:0.285766
## [74] train-logloss:0.282539 eval-logloss:0.282563
## [75] train-logloss:0.279412 eval-logloss:0.279434
```

```
## [76] train-logloss:0.276203 eval-logloss:0.276226
## [77] train-logloss:0.273120 eval-logloss:0.273139
## [78] train-logloss:0.269994 eval-logloss:0.270013
## [79] train-logloss:0.266909 eval-logloss:0.266928
## [80] train-logloss:0.263864 eval-logloss:0.263883
## [81] train-logloss:0.260858 eval-logloss:0.260878
## [82] train-logloss:0.258431 eval-logloss:0.258464
## [83] train-logloss:0.255496 eval-logloss:0.255529
## [84] train-logloss:0.252710 eval-logloss:0.252741
## [85] train-logloss:0.251221 eval-logloss:0.251254
## [86] train-logloss:0.248378 eval-logloss:0.248411
## [87] train-logloss:0.245650 eval-logloss:0.245679
## [88] train-logloss:0.242964 eval-logloss:0.242990
## [89] train-logloss:0.240226 eval-logloss:0.240252
## [90] train-logloss:0.238026 eval-logloss:0.238065
## [91] train-logloss:0.235350 eval-logloss:0.235389
## [92] train-logloss:0.232708 eval-logloss:0.232747
## [93] train-logloss:0.230099 eval-logloss:0.230139
## [94] train-logloss:0.227523 eval-logloss:0.227563
## [95] train-logloss:0.224980 eval-logloss:0.225020
## [96] train-logloss:0.222970 eval-logloss:0.223016
## [97] train-logloss:0.220558 eval-logloss:0.220600
## [98] train-logloss:0.218167 eval-logloss:0.218210
## [99] train-logloss:0.215740 eval-logloss:0.215782
## [100] train-logloss:0.213409 eval-logloss:0.213450
## [101] train-logloss:0.211040 eval-logloss:0.211082
## [102] train-logloss:0.208700 eval-logloss:0.208742
## [103] train-logloss:0.206455 eval-logloss:0.206496
## [104] train-logloss:0.204171 eval-logloss:0.204213
## [105] train-logloss:0.201916 eval-logloss:0.201957
## [106] train-logloss:0.200616 eval-logloss:0.200660
## [107] train-logloss:0.199481 eval-logloss:0.199527
## [108] train-logloss:0.197398 eval-logloss:0.197443
## [109] train-logloss:0.195659 eval-logloss:0.195716
## [110] train-logloss:0.193507 eval-logloss:0.193564
## [111] train-logloss:0.191380 eval-logloss:0.191438
## [112] train-logloss:0.189703 eval-logloss:0.189771
## [113] train-logloss:0.187622 eval-logloss:0.187690
## [114] train-logloss:0.185629 eval-logloss:0.185696
## [115] train-logloss:0.183597 eval-logloss:0.183665
## [116] train-logloss:0.182618 eval-logloss:0.182687
## [117] train-logloss:0.181617 eval-logloss:0.181689
## [118] train-logloss:0.179634 eval-logloss:0.179705
## [119] train-logloss:0.177674 eval-logloss:0.177744
## [120] train-logloss:0.175737 eval-logloss:0.175808
## [121] train-logloss:0.173883 eval-logloss:0.173953
## [122] train-logloss:0.171992 eval-logloss:0.172061
## [123] train-logloss:0.170122 eval-logloss:0.170192
## [124] train-logloss:0.168275 eval-logloss:0.168344
## [125] train-logloss:0.166450 eval-logloss:0.166519
## [126] train-logloss:0.164703 eval-logloss:0.164772
## [127] train-logloss:0.162920 eval-logloss:0.162988
## [128] train-logloss:0.162051 eval-logloss:0.162121
## [129] train-logloss:0.160299 eval-logloss:0.160368
```

```
## [130] train-logloss:0.158939 eval-logloss:0.159018
## [131] train-logloss:0.157223 eval-logloss:0.157301
## [132] train-logloss:0.155527 eval-logloss:0.155605
## [133] train-logloss:0.153851 eval-logloss:0.153929
## [134] train-logloss:0.152195 eval-logloss:0.152271
## [135] train-logloss:0.150557 eval-logloss:0.150634
## [136] train-logloss:0.148939 eval-logloss:0.149015
## [137] train-logloss:0.147418 eval-logloss:0.147495
## [138] train-logloss:0.145835 eval-logloss:0.145912
## [139] train-logloss:0.144347 eval-logloss:0.144422
## [140] train-logloss:0.142800 eval-logloss:0.142875
## [141] train-logloss:0.141610 eval-logloss:0.141690
## [142] train-logloss:0.140095 eval-logloss:0.140175
## [143] train-logloss:0.138597 eval-logloss:0.138677
## [144] train-logloss:0.137174 eval-logloss:0.137251
## [145] train-logloss:0.135709 eval-logloss:0.135786
## [146] train-logloss:0.134343 eval-logloss:0.134417
## [147] train-logloss:0.132911 eval-logloss:0.132985
## [148] train-logloss:0.132243 eval-logloss:0.132318
## [149] train-logloss:0.130835 eval-logloss:0.130909
## [150] train-logloss:0.129524 eval-logloss:0.129597
## [151] train-logloss:0.128147 eval-logloss:0.128219
## [152] train-logloss:0.126785 eval-logloss:0.126857
## [153] train-logloss:0.125438 eval-logloss:0.125510
## [154] train-logloss:0.124157 eval-logloss:0.124228
## [155] train-logloss:0.122840 eval-logloss:0.122911
## [156] train-logloss:0.121538 eval-logloss:0.121609
## [157] train-logloss:0.120324 eval-logloss:0.120395
## [158] train-logloss:0.119050 eval-logloss:0.119121
## [159] train-logloss:0.117791 eval-logloss:0.117862
## [160] train-logloss:0.116833 eval-logloss:0.116908
## [161] train-logloss:0.115598 eval-logloss:0.115673
## [162] train-logloss:0.114429 eval-logloss:0.114503
## [163] train-logloss:0.113269 eval-logloss:0.113342
## [164] train-logloss:0.112075 eval-logloss:0.112147
## [165] train-logloss:0.110893 eval-logloss:0.110966
## [166] train-logloss:0.109796 eval-logloss:0.109867
## [167] train-logloss:0.108690 eval-logloss:0.108759
## [168] train-logloss:0.107546 eval-logloss:0.107615
## [169] train-logloss:0.107010 eval-logloss:0.107081
## [170] train-logloss:0.106479 eval-logloss:0.106553
## [171] train-logloss:0.105406 eval-logloss:0.105478
## [172] train-logloss:0.104908 eval-logloss:0.104981
## [173] train-logloss:0.103885 eval-logloss:0.103957
## [174] train-logloss:0.102876 eval-logloss:0.102947
## [175] train-logloss:0.101796 eval-logloss:0.101867
## [176] train-logloss:0.100992 eval-logloss:0.101069
## [177] train-logloss:0.099933 eval-logloss:0.100010
## [178] train-logloss:0.098935 eval-logloss:0.099011
## [179] train-logloss:0.098460 eval-logloss:0.098538
## [180] train-logloss:0.097429 eval-logloss:0.097507
## [181] train-logloss:0.096409 eval-logloss:0.096487
## [182] train-logloss:0.095470 eval-logloss:0.095546
## [183] train-logloss:0.094472 eval-logloss:0.094548
```

```
## [184] train-logloss:0.093485 eval-logloss:0.093560
## [185] train-logloss:0.092508 eval-logloss:0.092583
## [186] train-logloss:0.091542 eval-logloss:0.091617
## [187] train-logloss:0.091108 eval-logloss:0.091185
## [188] train-logloss:0.090157 eval-logloss:0.090234
## [189] train-logloss:0.089736 eval-logloss:0.089815
## [190] train-logloss:0.088800 eval-logloss:0.088879
## [191] train-logloss:0.087916 eval-logloss:0.087994
## [192] train-logloss:0.087062 eval-logloss:0.087138
## [193] train-logloss:0.086155 eval-logloss:0.086231
## [194] train-logloss:0.085321 eval-logloss:0.085396
## [195] train-logloss:0.084666 eval-logloss:0.084747
## [196] train-logloss:0.084277 eval-logloss:0.084359
## [197] train-logloss:0.083401 eval-logloss:0.083482
## [198] train-logloss:0.082534 eval-logloss:0.082614
## [199] train-logloss:0.081677 eval-logloss:0.081756
## [200] train-logloss:0.080868 eval-logloss:0.080948
## [201] train-logloss:0.080028 eval-logloss:0.080108
## [202] train-logloss:0.079265 eval-logloss:0.079343
## [203] train-logloss:0.078507 eval-logloss:0.078584
## [204] train-logloss:0.077693 eval-logloss:0.077770
## [205] train-logloss:0.076887 eval-logloss:0.076964
## [206] train-logloss:0.076134 eval-logloss:0.076210
## [207] train-logloss:0.075346 eval-logloss:0.075421
## [208] train-logloss:0.074604 eval-logloss:0.074680
## [209] train-logloss:0.073832 eval-logloss:0.073907
## [210] train-logloss:0.073069 eval-logloss:0.073144
## [211] train-logloss:0.072313 eval-logloss:0.072388
## [212] train-logloss:0.071620 eval-logloss:0.071695
## [213] train-logloss:0.070921 eval-logloss:0.070996
## [214] train-logloss:0.070246 eval-logloss:0.070319
## [215] train-logloss:0.069572 eval-logloss:0.069646
## [216] train-logloss:0.068854 eval-logloss:0.068928
## [217] train-logloss:0.068144 eval-logloss:0.068217
## [218] train-logloss:0.067441 eval-logloss:0.067513
## [219] train-logloss:0.066746 eval-logloss:0.066817
## [220] train-logloss:0.066058 eval-logloss:0.066129
## [221] train-logloss:0.065416 eval-logloss:0.065488
## [222] train-logloss:0.064743 eval-logloss:0.064814
## [223] train-logloss:0.064076 eval-logloss:0.064147
## [224] train-logloss:0.063417 eval-logloss:0.063487
## [225] train-logloss:0.062765 eval-logloss:0.062834
## [226] train-logloss:0.062119 eval-logloss:0.062189
## [227] train-logloss:0.061481 eval-logloss:0.061549
## [228] train-logloss:0.060849 eval-logloss:0.060917
## [229] train-logloss:0.060224 eval-logloss:0.060291
## [230] train-logloss:0.059605 eval-logloss:0.059672
## [231] train-logloss:0.058994 eval-logloss:0.059060
## [232] train-logloss:0.058388 eval-logloss:0.058455
## [233] train-logloss:0.057830 eval-logloss:0.057896
## [234] train-logloss:0.057271 eval-logloss:0.057338
## [235] train-logloss:0.056684 eval-logloss:0.056750
## [236] train-logloss:0.056103 eval-logloss:0.056169
## [237] train-logloss:0.055561 eval-logloss:0.055628
```

```
## [238] train-logloss:0.054992 eval-logloss:0.055059
## [239] train-logloss:0.054429 eval-logloss:0.054495
## [240] train-logloss:0.053905 eval-logloss:0.053971
## [241] train-logloss:0.053354 eval-logloss:0.053419
## [242] train-logloss:0.052960 eval-logloss:0.053028
## [243] train-logloss:0.052451 eval-logloss:0.052520
## [244] train-logloss:0.051915 eval-logloss:0.051983
## [245] train-logloss:0.051688 eval-logloss:0.051757
## [246] train-logloss:0.051159 eval-logloss:0.051228
## [247] train-logloss:0.050636 eval-logloss:0.050705
## [248] train-logloss:0.050119 eval-logloss:0.050188
## [249] train-logloss:0.049637 eval-logloss:0.049706
## [250] train-logloss:0.049131 eval-logloss:0.049199
## [251] train-logloss:0.048661 eval-logloss:0.048730
## [252] train-logloss:0.048164 eval-logloss:0.048233
## [253] train-logloss:0.047703 eval-logloss:0.047772
## [254] train-logloss:0.047251 eval-logloss:0.047321
## [255] train-logloss:0.046769 eval-logloss:0.046839
## [256] train-logloss:0.046292 eval-logloss:0.046362
## [257] train-logloss:0.045852 eval-logloss:0.045920
## [258] train-logloss:0.045385 eval-logloss:0.045453
## [259] train-logloss:0.044923 eval-logloss:0.044990
## [260] train-logloss:0.044498 eval-logloss:0.044566
## [261] train-logloss:0.044087 eval-logloss:0.044154
## [262] train-logloss:0.043638 eval-logloss:0.043705
## [263] train-logloss:0.043451 eval-logloss:0.043520
## [264] train-logloss:0.043266 eval-logloss:0.043337
## [265] train-logloss:0.042826 eval-logloss:0.042896
## [266] train-logloss:0.042390 eval-logloss:0.042459
## [267] train-logloss:0.041959 eval-logloss:0.042027
## [268] train-logloss:0.041785 eval-logloss:0.041855
## [269] train-logloss:0.041360 eval-logloss:0.041430
## [270] train-logloss:0.040977 eval-logloss:0.041047
## [271] train-logloss:0.040592 eval-logloss:0.040663
## [272] train-logloss:0.040179 eval-logloss:0.040249
## [273] train-logloss:0.039771 eval-logloss:0.039841
## [274] train-logloss:0.039367 eval-logloss:0.039436
## [275] train-logloss:0.038967 eval-logloss:0.039036
## [276] train-logloss:0.038572 eval-logloss:0.038640
## [277] train-logloss:0.038223 eval-logloss:0.038291
## [278] train-logloss:0.038069 eval-logloss:0.038139
## [279] train-logloss:0.037798 eval-logloss:0.037869
## [280] train-logloss:0.037415 eval-logloss:0.037486
## [281] train-logloss:0.037064 eval-logloss:0.037134
## [282] train-logloss:0.036716 eval-logloss:0.036787
## [283] train-logloss:0.036571 eval-logloss:0.036643
## [284] train-logloss:0.036200 eval-logloss:0.036272
## [285] train-logloss:0.035861 eval-logloss:0.035932
## [286] train-logloss:0.035497 eval-logloss:0.035568
## [287] train-logloss:0.035138 eval-logloss:0.035208
## [288] train-logloss:0.034781 eval-logloss:0.034851
## [289] train-logloss:0.034429 eval-logloss:0.034498
## [290] train-logloss:0.034108 eval-logloss:0.034178
## [291] train-logloss:0.033762 eval-logloss:0.033832
```

```
## [292] train-logloss:0.033421 eval-logloss:0.033490
## [293] train-logloss:0.033113 eval-logloss:0.033183
## [294] train-logloss:0.032778 eval-logloss:0.032847
## [295] train-logloss:0.032650 eval-logloss:0.032720
## [296] train-logloss:0.032525 eval-logloss:0.032596
## [297] train-logloss:0.032195 eval-logloss:0.032266
## [298] train-logloss:0.031870 eval-logloss:0.031940
## [299] train-logloss:0.031547 eval-logloss:0.031618
## [300] train-logloss:0.031228 eval-logloss:0.031298
## [301] train-logloss:0.030912 eval-logloss:0.030981
## [302] train-logloss:0.030696 eval-logloss:0.030767
## [303] train-logloss:0.030385 eval-logloss:0.030456
## [304] train-logloss:0.030115 eval-logloss:0.030186
## [305] train-logloss:0.029810 eval-logloss:0.029881
## [306] train-logloss:0.029509 eval-logloss:0.029579
## [307] train-logloss:0.029211 eval-logloss:0.029281
## [308] train-logloss:0.028916 eval-logloss:0.028985
## [309] train-logloss:0.028655 eval-logloss:0.028724
## [310] train-logloss:0.028461 eval-logloss:0.028532
## [311] train-logloss:0.028174 eval-logloss:0.028244
## [312] train-logloss:0.027918 eval-logloss:0.027989
## [313] train-logloss:0.027662 eval-logloss:0.027733
## [314] train-logloss:0.027415 eval-logloss:0.027485
## [315] train-logloss:0.027162 eval-logloss:0.027233
## [316] train-logloss:0.026888 eval-logloss:0.026959
## [317] train-logloss:0.026650 eval-logloss:0.026720
## [318] train-logloss:0.026416 eval-logloss:0.026486
## [319] train-logloss:0.026149 eval-logloss:0.026219
## [320] train-logloss:0.025910 eval-logloss:0.025980
## [321] train-logloss:0.025649 eval-logloss:0.025718
## [322] train-logloss:0.025487 eval-logloss:0.025558
## [323] train-logloss:0.025230 eval-logloss:0.025301
## [324] train-logloss:0.024976 eval-logloss:0.025046
## [325] train-logloss:0.024756 eval-logloss:0.024826
## [326] train-logloss:0.024506 eval-logloss:0.024575
## [327] train-logloss:0.024259 eval-logloss:0.024328
## [328] train-logloss:0.024014 eval-logloss:0.024083
## [329] train-logloss:0.023796 eval-logloss:0.023865
## [330] train-logloss:0.023557 eval-logloss:0.023625
## [331] train-logloss:0.023320 eval-logloss:0.023388
## [332] train-logloss:0.023115 eval-logloss:0.023183
## [333] train-logloss:0.022882 eval-logloss:0.022949
## [334] train-logloss:0.022651 eval-logloss:0.022718
## [335] train-logloss:0.022569 eval-logloss:0.022638
## [336] train-logloss:0.022362 eval-logloss:0.022431
## [337] train-logloss:0.022137 eval-logloss:0.022206
## [338] train-logloss:0.021914 eval-logloss:0.021982
## [339] train-logloss:0.021770 eval-logloss:0.021839
## [340] train-logloss:0.021628 eval-logloss:0.021698
## [341] train-logloss:0.021536 eval-logloss:0.021608
## [342] train-logloss:0.021320 eval-logloss:0.021391
## [343] train-logloss:0.021106 eval-logloss:0.021176
## [344] train-logloss:0.021030 eval-logloss:0.021102
## [345] train-logloss:0.020895 eval-logloss:0.020969
```

```
## [346] train-logloss:0.020685 eval-logloss:0.020758
## [347] train-logloss:0.020477 eval-logloss:0.020549
## [348] train-logloss:0.020407 eval-logloss:0.020480
## [349] train-logloss:0.020336 eval-logloss:0.020410
## [350] train-logloss:0.020213 eval-logloss:0.020289
## [351] train-logloss:0.020010 eval-logloss:0.020085
## [352] train-logloss:0.019808 eval-logloss:0.019883
## [353] train-logloss:0.019609 eval-logloss:0.019684
## [354] train-logloss:0.019413 eval-logloss:0.019487
## [355] train-logloss:0.019240 eval-logloss:0.019314
## [356] train-logloss:0.019046 eval-logloss:0.019120
## [357] train-logloss:0.018936 eval-logloss:0.019011
## [358] train-logloss:0.018768 eval-logloss:0.018843
## [359] train-logloss:0.018580 eval-logloss:0.018655
## [360] train-logloss:0.018394 eval-logloss:0.018468
## [361] train-logloss:0.018333 eval-logloss:0.018408
## [362] train-logloss:0.018149 eval-logloss:0.018223
## [363] train-logloss:0.017967 eval-logloss:0.018041
## [364] train-logloss:0.017786 eval-logloss:0.017860
## [365] train-logloss:0.017635 eval-logloss:0.017709
## [366] train-logloss:0.017458 eval-logloss:0.017531
## [367] train-logloss:0.017283 eval-logloss:0.017355
## [368] train-logloss:0.017109 eval-logloss:0.017181
## [369] train-logloss:0.017009 eval-logloss:0.017082
## [370] train-logloss:0.016859 eval-logloss:0.016932
## [371] train-logloss:0.016690 eval-logloss:0.016763
## [372] train-logloss:0.016522 eval-logloss:0.016594
## [373] train-logloss:0.016356 eval-logloss:0.016428
## [374] train-logloss:0.016211 eval-logloss:0.016283
## [375] train-logloss:0.016049 eval-logloss:0.016120
## [376] train-logloss:0.015888 eval-logloss:0.015959
## [377] train-logloss:0.015729 eval-logloss:0.015800
## [378] train-logloss:0.015571 eval-logloss:0.015641
## [379] train-logloss:0.015415 eval-logloss:0.015484
## [380] train-logloss:0.015260 eval-logloss:0.015330
## [381] train-logloss:0.015108 eval-logloss:0.015176
## [382] train-logloss:0.014956 eval-logloss:0.015024
## [383] train-logloss:0.014806 eval-logloss:0.014874
## [384] train-logloss:0.014658 eval-logloss:0.014725
## [385] train-logloss:0.014533 eval-logloss:0.014601
## [386] train-logloss:0.014388 eval-logloss:0.014455
## [387] train-logloss:0.014261 eval-logloss:0.014328
## [388] train-logloss:0.014118 eval-logloss:0.014185
## [389] train-logloss:0.014038 eval-logloss:0.014106
## [390] train-logloss:0.013897 eval-logloss:0.013965
## [391] train-logloss:0.013816 eval-logloss:0.013885
## [392] train-logloss:0.013765 eval-logloss:0.013834
## [393] train-logloss:0.013627 eval-logloss:0.013696
## [394] train-logloss:0.013491 eval-logloss:0.013559
## [395] train-logloss:0.013372 eval-logloss:0.013440
## [396] train-logloss:0.013255 eval-logloss:0.013322
## [397] train-logloss:0.013123 eval-logloss:0.013189
## [398] train-logloss:0.013082 eval-logloss:0.013149
## [399] train-logloss:0.012951 eval-logloss:0.013017
```

```

## [400] train-logloss:0.012844 eval-logloss:0.012911
## [401] train-logloss:0.012715 eval-logloss:0.012782
## [402] train-logloss:0.012588 eval-logloss:0.012654
## [403] train-logloss:0.012550 eval-logloss:0.012616
## [404] train-logloss:0.012511 eval-logloss:0.012579
## [405] train-logloss:0.012406 eval-logloss:0.012474
## [406] train-logloss:0.012299 eval-logloss:0.012365
## [407] train-logloss:0.012176 eval-logloss:0.012242
## [408] train-logloss:0.012054 eval-logloss:0.012120
## [409] train-logloss:0.012018 eval-logloss:0.012085
## [410] train-logloss:0.011898 eval-logloss:0.011964
## [411] train-logloss:0.011779 eval-logloss:0.011845
## [412] train-logloss:0.011661 eval-logloss:0.011726
## [413] train-logloss:0.011544 eval-logloss:0.011609
## [414] train-logloss:0.011504 eval-logloss:0.011569
## [415] train-logloss:0.011405 eval-logloss:0.011469
## [416] train-logloss:0.011290 eval-logloss:0.011354
## [417] train-logloss:0.011257 eval-logloss:0.011322
## [418] train-logloss:0.011145 eval-logloss:0.011209
## [419] train-logloss:0.011034 eval-logloss:0.011097
## [420] train-logloss:0.010971 eval-logloss:0.011036
## [421] train-logloss:0.010877 eval-logloss:0.010941
## [422] train-logloss:0.010769 eval-logloss:0.010832
## [423] train-logloss:0.010712 eval-logloss:0.010776
## [424] train-logloss:0.010620 eval-logloss:0.010684
## [425] train-logloss:0.010514 eval-logloss:0.010577
## [426] train-logloss:0.010409 eval-logloss:0.010472
## [427] train-logloss:0.010305 eval-logloss:0.010367
## [428] train-logloss:0.010223 eval-logloss:0.010286
## [429] train-logloss:0.010121 eval-logloss:0.010183
## [430] train-logloss:0.010020 eval-logloss:0.010082
## [431] train-logloss:0.009937 eval-logloss:0.010000
## [432] train-logloss:0.009838 eval-logloss:0.009900
## [433] train-logloss:0.009754 eval-logloss:0.009815
## [434] train-logloss:0.009671 eval-logloss:0.009732
## [435] train-logloss:0.009575 eval-logloss:0.009635
## [436] train-logloss:0.009528 eval-logloss:0.009589
## [437] train-logloss:0.009501 eval-logloss:0.009563
## [438] train-logloss:0.009407 eval-logloss:0.009468
## [439] train-logloss:0.009313 eval-logloss:0.009373
## [440] train-logloss:0.009234 eval-logloss:0.009294
## [441] train-logloss:0.009142 eval-logloss:0.009202
## [442] train-logloss:0.009051 eval-logloss:0.009110
## [443] train-logloss:0.009027 eval-logloss:0.009086
## [444] train-logloss:0.008955 eval-logloss:0.009015
## [445] train-logloss:0.008866 eval-logloss:0.008925
## [446] train-logloss:0.008777 eval-logloss:0.008837
## [447] train-logloss:0.008754 eval-logloss:0.008814
## [448] train-logloss:0.008667 eval-logloss:0.008726
## [449] train-logloss:0.008594 eval-logloss:0.008654
## [450] train-logloss:0.008509 eval-logloss:0.008568
## [451] train-logloss:0.008424 eval-logloss:0.008483
## [452] train-logloss:0.008402 eval-logloss:0.008462
## [453] train-logloss:0.008337 eval-logloss:0.008397

```

```
## [454] train-logloss:0.008272 eval-logloss:0.008333
## [455] train-logloss:0.008190 eval-logloss:0.008250
## [456] train-logloss:0.008169 eval-logloss:0.008230
## [457] train-logloss:0.008088 eval-logloss:0.008148
## [458] train-logloss:0.008007 eval-logloss:0.008067
## [459] train-logloss:0.007987 eval-logloss:0.008047
## [460] train-logloss:0.007907 eval-logloss:0.007967
## [461] train-logloss:0.007828 eval-logloss:0.007888
## [462] train-logloss:0.007763 eval-logloss:0.007823
## [463] train-logloss:0.007685 eval-logloss:0.007745
## [464] train-logloss:0.007666 eval-logloss:0.007726
## [465] train-logloss:0.007602 eval-logloss:0.007662
## [466] train-logloss:0.007567 eval-logloss:0.007628
## [467] train-logloss:0.007491 eval-logloss:0.007552
## [468] train-logloss:0.007417 eval-logloss:0.007477
## [469] train-logloss:0.007383 eval-logloss:0.007443
## [470] train-logloss:0.007309 eval-logloss:0.007369
## [471] train-logloss:0.007237 eval-logloss:0.007296
## [472] train-logloss:0.007165 eval-logloss:0.007224
## [473] train-logloss:0.007094 eval-logloss:0.007152
## [474] train-logloss:0.007077 eval-logloss:0.007136
## [475] train-logloss:0.007006 eval-logloss:0.007066
## [476] train-logloss:0.006974 eval-logloss:0.007034
## [477] train-logloss:0.006905 eval-logloss:0.006965
## [478] train-logloss:0.006837 eval-logloss:0.006895
## [479] train-logloss:0.006821 eval-logloss:0.006880
## [480] train-logloss:0.006753 eval-logloss:0.006812
## [481] train-logloss:0.006686 eval-logloss:0.006745
## [482] train-logloss:0.006620 eval-logloss:0.006678
## [483] train-logloss:0.006589 eval-logloss:0.006648
## [484] train-logloss:0.006535 eval-logloss:0.006594
## [485] train-logloss:0.006484 eval-logloss:0.006543
## [486] train-logloss:0.006420 eval-logloss:0.006478
## [487] train-logloss:0.006356 eval-logloss:0.006415
## [488] train-logloss:0.006293 eval-logloss:0.006351
## [489] train-logloss:0.006242 eval-logloss:0.006299
## [490] train-logloss:0.006227 eval-logloss:0.006286
## [491] train-logloss:0.006199 eval-logloss:0.006258
## [492] train-logloss:0.006152 eval-logloss:0.006210
## [493] train-logloss:0.006091 eval-logloss:0.006149
## [494] train-logloss:0.006042 eval-logloss:0.006099
## [495] train-logloss:0.006015 eval-logloss:0.006073
## [496] train-logloss:0.005955 eval-logloss:0.006012
## [497] train-logloss:0.005896 eval-logloss:0.005953
## [498] train-logloss:0.005837 eval-logloss:0.005894
## [499] train-logloss:0.005825 eval-logloss:0.005882
## [500] train-logloss:0.005767 eval-logloss:0.005823
## [501] train-logloss:0.005720 eval-logloss:0.005777
## [502] train-logloss:0.005664 eval-logloss:0.005720
## [503] train-logloss:0.005619 eval-logloss:0.005674
## [504] train-logloss:0.005574 eval-logloss:0.005630
## [505] train-logloss:0.005519 eval-logloss:0.005574
## [506] train-logloss:0.005495 eval-logloss:0.005551
## [507] train-logloss:0.005451 eval-logloss:0.005508
```

```
## [508] train-logloss:0.005397 eval-logloss:0.005453
## [509] train-logloss:0.005344 eval-logloss:0.005399
## [510] train-logloss:0.005291 eval-logloss:0.005346
## [511] train-logloss:0.005268 eval-logloss:0.005324
## [512] train-logloss:0.005216 eval-logloss:0.005271
## [513] train-logloss:0.005175 eval-logloss:0.005230
## [514] train-logloss:0.005124 eval-logloss:0.005178
## [515] train-logloss:0.005073 eval-logloss:0.005127
## [516] train-logloss:0.005052 eval-logloss:0.005107
## [517] train-logloss:0.005002 eval-logloss:0.005056
## [518] train-logloss:0.004952 eval-logloss:0.005006
## [519] train-logloss:0.004903 eval-logloss:0.004957
## [520] train-logloss:0.004893 eval-logloss:0.004947
## [521] train-logloss:0.004855 eval-logloss:0.004909
## [522] train-logloss:0.004845 eval-logloss:0.004899
## [523] train-logloss:0.004796 eval-logloss:0.004851
## [524] train-logloss:0.004787 eval-logloss:0.004842
## [525] train-logloss:0.004740 eval-logloss:0.004794
## [526] train-logloss:0.004703 eval-logloss:0.004758
## [527] train-logloss:0.004666 eval-logloss:0.004721
## [528] train-logloss:0.004630 eval-logloss:0.004685
## [529] train-logloss:0.004584 eval-logloss:0.004639
## [530] train-logloss:0.004551 eval-logloss:0.004607
## [531] train-logloss:0.004506 eval-logloss:0.004561
## [532] train-logloss:0.004461 eval-logloss:0.004516
## [533] train-logloss:0.004417 eval-logloss:0.004471
## [534] train-logloss:0.004374 eval-logloss:0.004428
## [535] train-logloss:0.004331 eval-logloss:0.004384
## [536] train-logloss:0.004288 eval-logloss:0.004341
## [537] train-logloss:0.004245 eval-logloss:0.004298
## [538] train-logloss:0.004203 eval-logloss:0.004256
## [539] train-logloss:0.004162 eval-logloss:0.004214
## [540] train-logloss:0.004121 eval-logloss:0.004173
## [541] train-logloss:0.004080 eval-logloss:0.004132
## [542] train-logloss:0.004040 eval-logloss:0.004091
## [543] train-logloss:0.004000 eval-logloss:0.004050
## [544] train-logloss:0.003984 eval-logloss:0.004036
## [545] train-logloss:0.003954 eval-logloss:0.004006
## [546] train-logloss:0.003916 eval-logloss:0.003967
## [547] train-logloss:0.003877 eval-logloss:0.003928
## [548] train-logloss:0.003848 eval-logloss:0.003899
## [549] train-logloss:0.003810 eval-logloss:0.003861
## [550] train-logloss:0.003772 eval-logloss:0.003823
## [551] train-logloss:0.003745 eval-logloss:0.003796
## [552] train-logloss:0.003708 eval-logloss:0.003758
## [553] train-logloss:0.003679 eval-logloss:0.003730
## [554] train-logloss:0.003654 eval-logloss:0.003704
## [555] train-logloss:0.003617 eval-logloss:0.003668
## [556] train-logloss:0.003582 eval-logloss:0.003632
## [557] train-logloss:0.003555 eval-logloss:0.003605
## [558] train-logloss:0.003529 eval-logloss:0.003579
## [559] train-logloss:0.003504 eval-logloss:0.003555
## [560] train-logloss:0.003498 eval-logloss:0.003549
## [561] train-logloss:0.003463 eval-logloss:0.003514
```

```
## [562] train-logloss:0.003429 eval-logloss:0.003479
## [563] train-logloss:0.003403 eval-logloss:0.003454
## [564] train-logloss:0.003370 eval-logloss:0.003420
## [565] train-logloss:0.003364 eval-logloss:0.003414
## [566] train-logloss:0.003340 eval-logloss:0.003391
## [567] train-logloss:0.003315 eval-logloss:0.003366
## [568] train-logloss:0.003291 eval-logloss:0.003341
## [569] train-logloss:0.003259 eval-logloss:0.003309
## [570] train-logloss:0.003227 eval-logloss:0.003276
## [571] train-logloss:0.003195 eval-logloss:0.003244
## [572] train-logloss:0.003173 eval-logloss:0.003222
## [573] train-logloss:0.003142 eval-logloss:0.003190
## [574] train-logloss:0.003136 eval-logloss:0.003185
## [575] train-logloss:0.003105 eval-logloss:0.003154
## [576] train-logloss:0.003095 eval-logloss:0.003143
## [577] train-logloss:0.003064 eval-logloss:0.003113
## [578] train-logloss:0.003042 eval-logloss:0.003090
## [579] train-logloss:0.003020 eval-logloss:0.003068
## [580] train-logloss:0.003010 eval-logloss:0.003059
## [581] train-logloss:0.002981 eval-logloss:0.003029
## [582] train-logloss:0.002951 eval-logloss:0.003000
## [583] train-logloss:0.002922 eval-logloss:0.002970
## [584] train-logloss:0.002894 eval-logloss:0.002942
## [585] train-logloss:0.002865 eval-logloss:0.002913
## [586] train-logloss:0.002846 eval-logloss:0.002894
## [587] train-logloss:0.002837 eval-logloss:0.002885
## [588] train-logloss:0.002816 eval-logloss:0.002864
## [589] train-logloss:0.002789 eval-logloss:0.002837
## [590] train-logloss:0.002769 eval-logloss:0.002817
## [591] train-logloss:0.002749 eval-logloss:0.002797
## [592] train-logloss:0.002722 eval-logloss:0.002770
## [593] train-logloss:0.002703 eval-logloss:0.002751
## [594] train-logloss:0.002686 eval-logloss:0.002734
## [595] train-logloss:0.002659 eval-logloss:0.002707
## [596] train-logloss:0.002634 eval-logloss:0.002681
## [597] train-logloss:0.002616 eval-logloss:0.002664
## [598] train-logloss:0.002591 eval-logloss:0.002639
## [599] train-logloss:0.002573 eval-logloss:0.002621
## [600] train-logloss:0.002547 eval-logloss:0.002595
## [601] train-logloss:0.002543 eval-logloss:0.002591
## [602] train-logloss:0.002518 eval-logloss:0.002565
## [603] train-logloss:0.002493 eval-logloss:0.002541
## [604] train-logloss:0.002469 eval-logloss:0.002516
## [605] train-logloss:0.002445 eval-logloss:0.002491
## [606] train-logloss:0.002421 eval-logloss:0.002467
## [607] train-logloss:0.002397 eval-logloss:0.002443
## [608] train-logloss:0.002373 eval-logloss:0.002419
## [609] train-logloss:0.002350 eval-logloss:0.002396
## [610] train-logloss:0.002327 eval-logloss:0.002372
## [611] train-logloss:0.002312 eval-logloss:0.002357
## [612] train-logloss:0.002289 eval-logloss:0.002334
## [613] train-logloss:0.002266 eval-logloss:0.002311
## [614] train-logloss:0.002263 eval-logloss:0.002308
## [615] train-logloss:0.002241 eval-logloss:0.002285
```

```
## [616] train-logloss:0.002227 eval-logloss:0.002272
## [617] train-logloss:0.002213 eval-logloss:0.002258
## [618] train-logloss:0.002191 eval-logloss:0.002236
## [619] train-logloss:0.002188 eval-logloss:0.002233
## [620] train-logloss:0.002173 eval-logloss:0.002218
## [621] train-logloss:0.002159 eval-logloss:0.002205
## [622] train-logloss:0.002138 eval-logloss:0.002184
## [623] train-logloss:0.002117 eval-logloss:0.002162
## [624] train-logloss:0.002104 eval-logloss:0.002150
## [625] train-logloss:0.002084 eval-logloss:0.002129
## [626] train-logloss:0.002064 eval-logloss:0.002109
## [627] train-logloss:0.002044 eval-logloss:0.002088
## [628] train-logloss:0.002037 eval-logloss:0.002082
## [629] train-logloss:0.002025 eval-logloss:0.002070
## [630] train-logloss:0.002013 eval-logloss:0.002058
## [631] train-logloss:0.002000 eval-logloss:0.002045
## [632] train-logloss:0.001980 eval-logloss:0.002025
## [633] train-logloss:0.001961 eval-logloss:0.002005
## [634] train-logloss:0.001941 eval-logloss:0.001986
## [635] train-logloss:0.001923 eval-logloss:0.001967
## [636] train-logloss:0.001904 eval-logloss:0.001948
## [637] train-logloss:0.001901 eval-logloss:0.001945
## [638] train-logloss:0.001883 eval-logloss:0.001927
## [639] train-logloss:0.001880 eval-logloss:0.001924
## [640] train-logloss:0.001870 eval-logloss:0.001914
## [641] train-logloss:0.001852 eval-logloss:0.001896
## [642] train-logloss:0.001834 eval-logloss:0.001878
## [643] train-logloss:0.001816 eval-logloss:0.001860
## [644] train-logloss:0.001804 eval-logloss:0.001849
## [645] train-logloss:0.001802 eval-logloss:0.001846
## [646] train-logloss:0.001784 eval-logloss:0.001829
## [647] train-logloss:0.001767 eval-logloss:0.001812
## [648] train-logloss:0.001750 eval-logloss:0.001794
## [649] train-logloss:0.001733 eval-logloss:0.001777
## [650] train-logloss:0.001722 eval-logloss:0.001766
## [651] train-logloss:0.001717 eval-logloss:0.001762
## [652] train-logloss:0.001715 eval-logloss:0.001760
## [653] train-logloss:0.001698 eval-logloss:0.001743
## [654] train-logloss:0.001687 eval-logloss:0.001732
## [655] train-logloss:0.001671 eval-logloss:0.001715
## [656] train-logloss:0.001655 eval-logloss:0.001698
## [657] train-logloss:0.001650 eval-logloss:0.001694
## [658] train-logloss:0.001640 eval-logloss:0.001685
## [659] train-logloss:0.001624 eval-logloss:0.001668
## [660] train-logloss:0.001614 eval-logloss:0.001658
## [661] train-logloss:0.001598 eval-logloss:0.001642
## [662] train-logloss:0.001583 eval-logloss:0.001626
## [663] train-logloss:0.001579 eval-logloss:0.001622
## [664] train-logloss:0.001564 eval-logloss:0.001607
## [665] train-logloss:0.001554 eval-logloss:0.001597
## [666] train-logloss:0.001544 eval-logloss:0.001588
## [667] train-logloss:0.001529 eval-logloss:0.001573
## [668] train-logloss:0.001527 eval-logloss:0.001571
## [669] train-logloss:0.001518 eval-logloss:0.001562
```

```

## [670] train-logloss:0.001503 eval-logloss:0.001547
## [671] train-logloss:0.001489 eval-logloss:0.001532
## [672] train-logloss:0.001474 eval-logloss:0.001517
## [673] train-logloss:0.001460 eval-logloss:0.001503
## [674] train-logloss:0.001446 eval-logloss:0.001489
## [675] train-logloss:0.001432 eval-logloss:0.001475
## [676] train-logloss:0.001424 eval-logloss:0.001467
## [677] train-logloss:0.001411 eval-logloss:0.001453
## [678] train-logloss:0.001397 eval-logloss:0.001439
## [679] train-logloss:0.001390 eval-logloss:0.001432
## [680] train-logloss:0.001376 eval-logloss:0.001418
## [681] train-logloss:0.001363 eval-logloss:0.001405
## [682] train-logloss:0.001349 eval-logloss:0.001391
## [683] train-logloss:0.001342 eval-logloss:0.001384
## [684] train-logloss:0.001329 eval-logloss:0.001371
## [685] train-logloss:0.001317 eval-logloss:0.001358
## [686] train-logloss:0.001304 eval-logloss:0.001345
## [687] train-logloss:0.001297 eval-logloss:0.001338
## [688] train-logloss:0.001289 eval-logloss:0.001330
## [689] train-logloss:0.001282 eval-logloss:0.001323
## [690] train-logloss:0.001269 eval-logloss:0.001311
## [691] train-logloss:0.001262 eval-logloss:0.001303
## [692] train-logloss:0.001259 eval-logloss:0.001300
## [693] train-logloss:0.001247 eval-logloss:0.001288
## [694] train-logloss:0.001235 eval-logloss:0.001275
## [695] train-logloss:0.001223 eval-logloss:0.001263
## [696] train-logloss:0.001211 eval-logloss:0.001251
## [697] train-logloss:0.001199 eval-logloss:0.001239
## [698] train-logloss:0.001192 eval-logloss:0.001232
## [699] train-logloss:0.001180 eval-logloss:0.001220
## [700] train-logloss:0.001169 eval-logloss:0.001208
## [701] train-logloss:0.001162 eval-logloss:0.001202
## [702] train-logloss:0.001161 eval-logloss:0.001200
## [703] train-logloss:0.001155 eval-logloss:0.001194
## [704] train-logloss:0.001143 eval-logloss:0.001183
## [705] train-logloss:0.001138 eval-logloss:0.001177
## [706] train-logloss:0.001127 eval-logloss:0.001166
## [707] train-logloss:0.001120 eval-logloss:0.001160
## [708] train-logloss:0.001119 eval-logloss:0.001159
## [709] train-logloss:0.001108 eval-logloss:0.001147
## [710] train-logloss:0.001102 eval-logloss:0.001141
## [711] train-logloss:0.001096 eval-logloss:0.001136
## [712] train-logloss:0.001086 eval-logloss:0.001125
## [713] train-logloss:0.001075 eval-logloss:0.001114
## [714] train-logloss:0.001065 eval-logloss:0.001103
## [715] train-logloss:0.001055 eval-logloss:0.001093
## [716] train-logloss:0.001045 eval-logloss:0.001082
## [717] train-logloss:0.001035 eval-logloss:0.001072
## [718] train-logloss:0.001025 eval-logloss:0.001062
## [719] train-logloss:0.001015 eval-logloss:0.001052
## [720] train-logloss:0.001005 eval-logloss:0.001042
## [721] train-logloss:0.001000 eval-logloss:0.001036
## [722] train-logloss:0.000995 eval-logloss:0.001031
## [723] train-logloss:0.000985 eval-logloss:0.001022

```

```
## [724] train-logloss:0.000976 eval-logloss:0.001012
## [725] train-logloss:0.000967 eval-logloss:0.001002
## [726] train-logloss:0.000957 eval-logloss:0.000993
## [727] train-logloss:0.000956 eval-logloss:0.000992
## [728] train-logloss:0.000954 eval-logloss:0.000990
## [729] train-logloss:0.000945 eval-logloss:0.000980
## [730] train-logloss:0.000936 eval-logloss:0.000971
## [731] train-logloss:0.000932 eval-logloss:0.000967
## [732] train-logloss:0.000923 eval-logloss:0.000958
## [733] train-logloss:0.000918 eval-logloss:0.000953
## [734] train-logloss:0.000909 eval-logloss:0.000944
## [735] train-logloss:0.000907 eval-logloss:0.000942
## [736] train-logloss:0.000899 eval-logloss:0.000933
## [737] train-logloss:0.000894 eval-logloss:0.000929
## [738] train-logloss:0.000892 eval-logloss:0.000927
## [739] train-logloss:0.000884 eval-logloss:0.000918
## [740] train-logloss:0.000880 eval-logloss:0.000914
## [741] train-logloss:0.000871 eval-logloss:0.000906
## [742] train-logloss:0.000863 eval-logloss:0.000897
## [743] train-logloss:0.000855 eval-logloss:0.000889
## [744] train-logloss:0.000847 eval-logloss:0.000880
## [745] train-logloss:0.000839 eval-logloss:0.000872
## [746] train-logloss:0.000837 eval-logloss:0.000870
## [747] train-logloss:0.000829 eval-logloss:0.000862
## [748] train-logloss:0.000821 eval-logloss:0.000854
## [749] train-logloss:0.000817 eval-logloss:0.000850
## [750] train-logloss:0.000814 eval-logloss:0.000847
## [751] train-logloss:0.000806 eval-logloss:0.000839
## [752] train-logloss:0.000798 eval-logloss:0.000831
## [753] train-logloss:0.000797 eval-logloss:0.000830
## [754] train-logloss:0.000793 eval-logloss:0.000826
## [755] train-logloss:0.000786 eval-logloss:0.000818
## [756] train-logloss:0.000784 eval-logloss:0.000817
## [757] train-logloss:0.000777 eval-logloss:0.000809
## [758] train-logloss:0.000773 eval-logloss:0.000806
## [759] train-logloss:0.000770 eval-logloss:0.000803
## [760] train-logloss:0.000766 eval-logloss:0.000799
## [761] train-logloss:0.000763 eval-logloss:0.000796
## [762] train-logloss:0.000756 eval-logloss:0.000788
## [763] train-logloss:0.000749 eval-logloss:0.000781
## [764] train-logloss:0.000742 eval-logloss:0.000774
## [765] train-logloss:0.000741 eval-logloss:0.000773
## [766] train-logloss:0.000734 eval-logloss:0.000766
## [767] train-logloss:0.000733 eval-logloss:0.000765
## [768] train-logloss:0.000726 eval-logloss:0.000758
## [769] train-logloss:0.000723 eval-logloss:0.000755
## [770] train-logloss:0.000716 eval-logloss:0.000748
## [771] train-logloss:0.000709 eval-logloss:0.000741
## [772] train-logloss:0.000706 eval-logloss:0.000738
## [773] train-logloss:0.000703 eval-logloss:0.000735
## [774] train-logloss:0.000700 eval-logloss:0.000731
## [775] train-logloss:0.000697 eval-logloss:0.000729
## [776] train-logloss:0.000690 eval-logloss:0.000722
## [777] train-logloss:0.000687 eval-logloss:0.000719
```

```
## [778] train-logloss:0.000681 eval-logloss:0.000712
## [779] train-logloss:0.000677 eval-logloss:0.000709
## [780] train-logloss:0.000671 eval-logloss:0.000702
## [781] train-logloss:0.000668 eval-logloss:0.000700
## [782] train-logloss:0.000667 eval-logloss:0.000699
## [783] train-logloss:0.000667 eval-logloss:0.000698
## [784] train-logloss:0.000660 eval-logloss:0.000692
## [785] train-logloss:0.000654 eval-logloss:0.000685
## [786] train-logloss:0.000651 eval-logloss:0.000682
## [787] train-logloss:0.000645 eval-logloss:0.000676
## [788] train-logloss:0.000639 eval-logloss:0.000670
## [789] train-logloss:0.000633 eval-logloss:0.000664
## [790] train-logloss:0.000631 eval-logloss:0.000661
## [791] train-logloss:0.000625 eval-logloss:0.000655
## [792] train-logloss:0.000624 eval-logloss:0.000654
## [793] train-logloss:0.000621 eval-logloss:0.000652
## [794] train-logloss:0.000618 eval-logloss:0.000649
## [795] train-logloss:0.000615 eval-logloss:0.000646
## [796] train-logloss:0.000609 eval-logloss:0.000640
## [797] train-logloss:0.000604 eval-logloss:0.000634
## [798] train-logloss:0.000598 eval-logloss:0.000628
## [799] train-logloss:0.000593 eval-logloss:0.000623
## [800] train-logloss:0.000590 eval-logloss:0.000620
## [801] train-logloss:0.000589 eval-logloss:0.000619
## [802] train-logloss:0.000587 eval-logloss:0.000617
## [803] train-logloss:0.000584 eval-logloss:0.000615
## [804] train-logloss:0.000579 eval-logloss:0.000609
## [805] train-logloss:0.000573 eval-logloss:0.000603
## [806] train-logloss:0.000568 eval-logloss:0.000598
## [807] train-logloss:0.000563 eval-logloss:0.000592
## [808] train-logloss:0.000562 eval-logloss:0.000592
## [809] train-logloss:0.000560 eval-logloss:0.000589
## [810] train-logloss:0.000554 eval-logloss:0.000584
## [811] train-logloss:0.000549 eval-logloss:0.000578
## [812] train-logloss:0.000544 eval-logloss:0.000573
## [813] train-logloss:0.000542 eval-logloss:0.000571
## [814] train-logloss:0.000540 eval-logloss:0.000569
## [815] train-logloss:0.000535 eval-logloss:0.000563
## [816] train-logloss:0.000530 eval-logloss:0.000558
## [817] train-logloss:0.000525 eval-logloss:0.000553
## [818] train-logloss:0.000520 eval-logloss:0.000548
## [819] train-logloss:0.000515 eval-logloss:0.000543
## [820] train-logloss:0.000510 eval-logloss:0.000538
## [821] train-logloss:0.000506 eval-logloss:0.000533
## [822] train-logloss:0.000501 eval-logloss:0.000528
## [823] train-logloss:0.000496 eval-logloss:0.000523
## [824] train-logloss:0.000492 eval-logloss:0.000518
## [825] train-logloss:0.000490 eval-logloss:0.000516
## [826] train-logloss:0.000485 eval-logloss:0.000512
## [827] train-logloss:0.000481 eval-logloss:0.000507
## [828] train-logloss:0.000479 eval-logloss:0.000505
## [829] train-logloss:0.000477 eval-logloss:0.000504
## [830] train-logloss:0.000473 eval-logloss:0.000499
## [831] train-logloss:0.000468 eval-logloss:0.000494
```

```
## [832] train-logloss:0.000467 eval-logloss:0.000493
## [833] train-logloss:0.000462 eval-logloss:0.000488
## [834] train-logloss:0.000458 eval-logloss:0.000484
## [835] train-logloss:0.000458 eval-logloss:0.000484
## [836] train-logloss:0.000454 eval-logloss:0.000479
## [837] train-logloss:0.000453 eval-logloss:0.000479
## [838] train-logloss:0.000451 eval-logloss:0.000477
## [839] train-logloss:0.000447 eval-logloss:0.000473
## [840] train-logloss:0.000445 eval-logloss:0.000471
## [841] train-logloss:0.000441 eval-logloss:0.000467
## [842] train-logloss:0.000437 eval-logloss:0.000462
## [843] train-logloss:0.000436 eval-logloss:0.000461
## [844] train-logloss:0.000435 eval-logloss:0.000460
## [845] train-logloss:0.000431 eval-logloss:0.000456
## [846] train-logloss:0.000427 eval-logloss:0.000452
## [847] train-logloss:0.000423 eval-logloss:0.000447
## [848] train-logloss:0.000419 eval-logloss:0.000443
## [849] train-logloss:0.000415 eval-logloss:0.000439
## [850] train-logloss:0.000412 eval-logloss:0.000435
## [851] train-logloss:0.000410 eval-logloss:0.000434
## [852] train-logloss:0.000410 eval-logloss:0.000434
## [853] train-logloss:0.000408 eval-logloss:0.000432
## [854] train-logloss:0.000404 eval-logloss:0.000429
## [855] train-logloss:0.000401 eval-logloss:0.000425
## [856] train-logloss:0.000397 eval-logloss:0.000421
## [857] train-logloss:0.000396 eval-logloss:0.000420
## [858] train-logloss:0.000395 eval-logloss:0.000419
## [859] train-logloss:0.000391 eval-logloss:0.000415
## [860] train-logloss:0.000390 eval-logloss:0.000413
## [861] train-logloss:0.000386 eval-logloss:0.000410
## [862] train-logloss:0.000386 eval-logloss:0.000409
## [863] train-logloss:0.000382 eval-logloss:0.000406
## [864] train-logloss:0.000379 eval-logloss:0.000402
## [865] train-logloss:0.000376 eval-logloss:0.000398
## [866] train-logloss:0.000372 eval-logloss:0.000395
## [867] train-logloss:0.000369 eval-logloss:0.000391
## [868] train-logloss:0.000368 eval-logloss:0.000390
## [869] train-logloss:0.000364 eval-logloss:0.000387
## [870] train-logloss:0.000361 eval-logloss:0.000383
## [871] train-logloss:0.000358 eval-logloss:0.000380
## [872] train-logloss:0.000355 eval-logloss:0.000376
## [873] train-logloss:0.000354 eval-logloss:0.000376
## [874] train-logloss:0.000351 eval-logloss:0.000373
## [875] train-logloss:0.000350 eval-logloss:0.000372
## [876] train-logloss:0.000350 eval-logloss:0.000372
## [877] train-logloss:0.000349 eval-logloss:0.000371
## [878] train-logloss:0.000346 eval-logloss:0.000367
## [879] train-logloss:0.000342 eval-logloss:0.000364
## [880] train-logloss:0.000339 eval-logloss:0.000361
## [881] train-logloss:0.000336 eval-logloss:0.000358
## [882] train-logloss:0.000333 eval-logloss:0.000354
## [883] train-logloss:0.000330 eval-logloss:0.000351
## [884] train-logloss:0.000328 eval-logloss:0.000348
## [885] train-logloss:0.000325 eval-logloss:0.000345
```

```
## [886] train-logloss:0.000322 eval-logloss:0.000342
## [887] train-logloss:0.000319 eval-logloss:0.000339
## [888] train-logloss:0.000316 eval-logloss:0.000336
## [889] train-logloss:0.000313 eval-logloss:0.000333
## [890] train-logloss:0.000311 eval-logloss:0.000330
## [891] train-logloss:0.000308 eval-logloss:0.000327
## [892] train-logloss:0.000308 eval-logloss:0.000327
## [893] train-logloss:0.000305 eval-logloss:0.000324
## [894] train-logloss:0.000302 eval-logloss:0.000322
## [895] train-logloss:0.000300 eval-logloss:0.000319
## [896] train-logloss:0.000297 eval-logloss:0.000316
## [897] train-logloss:0.000295 eval-logloss:0.000313
## [898] train-logloss:0.000292 eval-logloss:0.000311
## [899] train-logloss:0.000289 eval-logloss:0.000308
## [900] train-logloss:0.000287 eval-logloss:0.000305
## [901] train-logloss:0.000284 eval-logloss:0.000302
## [902] train-logloss:0.000282 eval-logloss:0.000300
## [903] train-logloss:0.000279 eval-logloss:0.000297
## [904] train-logloss:0.000277 eval-logloss:0.000295
## [905] train-logloss:0.000276 eval-logloss:0.000294
## [906] train-logloss:0.000274 eval-logloss:0.000291
## [907] train-logloss:0.000271 eval-logloss:0.000289
## [908] train-logloss:0.000269 eval-logloss:0.000286
## [909] train-logloss:0.000268 eval-logloss:0.000286
## [910] train-logloss:0.000268 eval-logloss:0.000285
## [911] train-logloss:0.000267 eval-logloss:0.000285
## [912] train-logloss:0.000267 eval-logloss:0.000284
## [913] train-logloss:0.000265 eval-logloss:0.000282
## [914] train-logloss:0.000263 eval-logloss:0.000280
## [915] train-logloss:0.000260 eval-logloss:0.000277
## [916] train-logloss:0.000260 eval-logloss:0.000277
## [917] train-logloss:0.000258 eval-logloss:0.000275
## [918] train-logloss:0.000256 eval-logloss:0.000272
## [919] train-logloss:0.000255 eval-logloss:0.000272
## [920] train-logloss:0.000253 eval-logloss:0.000269
## [921] train-logloss:0.000251 eval-logloss:0.000267
## [922] train-logloss:0.000248 eval-logloss:0.000265
## [923] train-logloss:0.000246 eval-logloss:0.000263
## [924] train-logloss:0.000244 eval-logloss:0.000260
## [925] train-logloss:0.000242 eval-logloss:0.000258
## [926] train-logloss:0.000242 eval-logloss:0.000258
## [927] train-logloss:0.000242 eval-logloss:0.000258
## [928] train-logloss:0.000240 eval-logloss:0.000256
## [929] train-logloss:0.000238 eval-logloss:0.000254
## [930] train-logloss:0.000237 eval-logloss:0.000253
## [931] train-logloss:0.000237 eval-logloss:0.000253
## [932] train-logloss:0.000237 eval-logloss:0.000253
## [933] train-logloss:0.000235 eval-logloss:0.000250
## [934] train-logloss:0.000234 eval-logloss:0.000250
## [935] train-logloss:0.000232 eval-logloss:0.000248
## [936] train-logloss:0.000230 eval-logloss:0.000246
## [937] train-logloss:0.000228 eval-logloss:0.000244
## [938] train-logloss:0.000226 eval-logloss:0.000242
## [939] train-logloss:0.000226 eval-logloss:0.000241
```

```
## [940] train-logloss:0.000225 eval-logloss:0.000240
## [941] train-logloss:0.000225 eval-logloss:0.000240
## [942] train-logloss:0.000224 eval-logloss:0.000240
## [943] train-logloss:0.000224 eval-logloss:0.000239
## [944] train-logloss:0.000223 eval-logloss:0.000239
## [945] train-logloss:0.000222 eval-logloss:0.000237
## [946] train-logloss:0.000220 eval-logloss:0.000235
## [947] train-logloss:0.000218 eval-logloss:0.000233
## [948] train-logloss:0.000216 eval-logloss:0.000231
## [949] train-logloss:0.000214 eval-logloss:0.000229
## [950] train-logloss:0.000212 eval-logloss:0.000227
## [951] train-logloss:0.000212 eval-logloss:0.000227
## [952] train-logloss:0.000212 eval-logloss:0.000227
## [953] train-logloss:0.000210 eval-logloss:0.000225
## [954] train-logloss:0.000209 eval-logloss:0.000224
## [955] train-logloss:0.000209 eval-logloss:0.000224
## [956] train-logloss:0.000208 eval-logloss:0.000223
## [957] train-logloss:0.000208 eval-logloss:0.000223
## [958] train-logloss:0.000208 eval-logloss:0.000223
## [959] train-logloss:0.000206 eval-logloss:0.000221
## [960] train-logloss:0.000206 eval-logloss:0.000221
## [961] train-logloss:0.000205 eval-logloss:0.000220
## [962] train-logloss:0.000204 eval-logloss:0.000218
## [963] train-logloss:0.000202 eval-logloss:0.000217
## [964] train-logloss:0.000201 eval-logloss:0.000216
## [965] train-logloss:0.000200 eval-logloss:0.000215
## [966] train-logloss:0.000200 eval-logloss:0.000214
## [967] train-logloss:0.000198 eval-logloss:0.000213
## [968] train-logloss:0.000198 eval-logloss:0.000212
## [969] train-logloss:0.000197 eval-logloss:0.000212
## [970] train-logloss:0.000197 eval-logloss:0.000211
## [971] train-logloss:0.000196 eval-logloss:0.000211
## [972] train-logloss:0.000194 eval-logloss:0.000209
## [973] train-logloss:0.000193 eval-logloss:0.000207
## [974] train-logloss:0.000192 eval-logloss:0.000207
## [975] train-logloss:0.000191 eval-logloss:0.000205
## [976] train-logloss:0.000190 eval-logloss:0.000205
## [977] train-logloss:0.000189 eval-logloss:0.000203
## [978] train-logloss:0.000187 eval-logloss:0.000202
## [979] train-logloss:0.000187 eval-logloss:0.000201
## [980] train-logloss:0.000185 eval-logloss:0.000200
## [981] train-logloss:0.000184 eval-logloss:0.000198
## [982] train-logloss:0.000184 eval-logloss:0.000198
## [983] train-logloss:0.000182 eval-logloss:0.000196
## [984] train-logloss:0.000182 eval-logloss:0.000196
## [985] train-logloss:0.000180 eval-logloss:0.000194
## [986] train-logloss:0.000179 eval-logloss:0.000193
## [987] train-logloss:0.000177 eval-logloss:0.000191
## [988] train-logloss:0.000177 eval-logloss:0.000191
## [989] train-logloss:0.000177 eval-logloss:0.000191
## [990] train-logloss:0.000176 eval-logloss:0.000190
## [991] train-logloss:0.000175 eval-logloss:0.000189
## [992] train-logloss:0.000173 eval-logloss:0.000187
## [993] train-logloss:0.000173 eval-logloss:0.000187
```

```

## [994]    train-logloss:0.000172  eval-logloss:0.000185
## [995]    train-logloss:0.000171  eval-logloss:0.000185
## [996]    train-logloss:0.000170  eval-logloss:0.000184
## [997]    train-logloss:0.000169  eval-logloss:0.000182
## [998]    train-logloss:0.000167  eval-logloss:0.000181
## [999]    train-logloss:0.000167  eval-logloss:0.000180
## [1000]   train-logloss:0.000167  eval-logloss:0.000180
## [1]     train-logloss:0.602108  eval-logloss:0.602058
## Multiple eval metrics are present. Will use eval_logloss for early stopping.
## Will train until eval_logloss hasn't improved in 10 rounds.
##
## [2]    train-logloss:0.526820  eval-logloss:0.526737
## [3]    train-logloss:0.464085  eval-logloss:0.463972
## [4]    train-logloss:0.407950  eval-logloss:0.407850
## [5]    train-logloss:0.362867  eval-logloss:0.362741
## [6]    train-logloss:0.324507  eval-logloss:0.324350
## [7]    train-logloss:0.288049  eval-logloss:0.287908
## [8]    train-logloss:0.256286  eval-logloss:0.256159
## [9]    train-logloss:0.228480  eval-logloss:0.228365
## [10]   train-logloss:0.204038  eval-logloss:0.203934
## [11]   train-logloss:0.184717  eval-logloss:0.184590
## [12]   train-logloss:0.167690  eval-logloss:0.167540
## [13]   train-logloss:0.152395  eval-logloss:0.152224
## [14]   train-logloss:0.136683  eval-logloss:0.136528
## [15]   train-logloss:0.122695  eval-logloss:0.122555
## [16]   train-logloss:0.112275  eval-logloss:0.112116
## [17]   train-logloss:0.102813  eval-logloss:0.102644
## [18]   train-logloss:0.094599  eval-logloss:0.094409
## [19]   train-logloss:0.089547  eval-logloss:0.089325
## [20]   train-logloss:0.082813  eval-logloss:0.082573
## [21]   train-logloss:0.076600  eval-logloss:0.076354
## [22]   train-logloss:0.071060  eval-logloss:0.070805
## [23]   train-logloss:0.066117  eval-logloss:0.065855
## [24]   train-logloss:0.061689  eval-logloss:0.061423
## [25]   train-logloss:0.057926  eval-logloss:0.057652
## [26]   train-logloss:0.054322  eval-logloss:0.054044
## [27]   train-logloss:0.052567  eval-logloss:0.052280
## [28]   train-logloss:0.049500  eval-logloss:0.049209
## [29]   train-logloss:0.044428  eval-logloss:0.044167
## [30]   train-logloss:0.039859  eval-logloss:0.039626
## [31]   train-logloss:0.037745  eval-logloss:0.037508
## [32]   train-logloss:0.033827  eval-logloss:0.033616
## [33]   train-logloss:0.032156  eval-logloss:0.031945
## [34]   train-logloss:0.030605  eval-logloss:0.030383
## [35]   train-logloss:0.027374  eval-logloss:0.027179
## [36]   train-logloss:0.026350  eval-logloss:0.026134
## [37]   train-logloss:0.025445  eval-logloss:0.025208
## [38]   train-logloss:0.024392  eval-logloss:0.024158
## [39]   train-logloss:0.023638  eval-logloss:0.023386
## [40]   train-logloss:0.021044  eval-logloss:0.020821
## [41]   train-logloss:0.018755  eval-logloss:0.018559
## [42]   train-logloss:0.016738  eval-logloss:0.016564
## [43]   train-logloss:0.016339  eval-logloss:0.016168
## [44]   train-logloss:0.014599  eval-logloss:0.014447

```

```
## [45] train-logloss:0.014208 eval-logloss:0.014035
## [46] train-logloss:0.012706 eval-logloss:0.012552
## [47] train-logloss:0.011379 eval-logloss:0.011241
## [48] train-logloss:0.010741 eval-logloss:0.010600
## [49] train-logloss:0.009631 eval-logloss:0.009505
## [50] train-logloss:0.009146 eval-logloss:0.008991
## [51] train-logloss:0.008961 eval-logloss:0.008806
## [52] train-logloss:0.008802 eval-logloss:0.008653
## [53] train-logloss:0.008399 eval-logloss:0.008254
## [54] train-logloss:0.008274 eval-logloss:0.008126
## [55] train-logloss:0.008077 eval-logloss:0.007921
## [56] train-logloss:0.007245 eval-logloss:0.007105
## [57] train-logloss:0.006973 eval-logloss:0.006834
## [58] train-logloss:0.006261 eval-logloss:0.006136
## [59] train-logloss:0.005627 eval-logloss:0.005515
## [60] train-logloss:0.005062 eval-logloss:0.004961
## [61] train-logloss:0.004557 eval-logloss:0.004466
## [62] train-logloss:0.004105 eval-logloss:0.004023
## [63] train-logloss:0.003701 eval-logloss:0.003627
## [64] train-logloss:0.003338 eval-logloss:0.003271
## [65] train-logloss:0.003012 eval-logloss:0.002952
## [66] train-logloss:0.002974 eval-logloss:0.002916
## [67] train-logloss:0.002686 eval-logloss:0.002633
## [68] train-logloss:0.002426 eval-logloss:0.002379
## [69] train-logloss:0.002193 eval-logloss:0.002150
## [70] train-logloss:0.001983 eval-logloss:0.001945
## [71] train-logloss:0.001934 eval-logloss:0.001899
## [72] train-logloss:0.001885 eval-logloss:0.001853
## [73] train-logloss:0.001706 eval-logloss:0.001677
## [74] train-logloss:0.001696 eval-logloss:0.001669
## [75] train-logloss:0.001536 eval-logloss:0.001511
## [76] train-logloss:0.001390 eval-logloss:0.001368
## [77] train-logloss:0.001354 eval-logloss:0.001333
## [78] train-logloss:0.001227 eval-logloss:0.001208
## [79] train-logloss:0.001217 eval-logloss:0.001199
## [80] train-logloss:0.001103 eval-logloss:0.001087
## [81] train-logloss:0.001001 eval-logloss:0.000985
## [82] train-logloss:0.000908 eval-logloss:0.000894
## [83] train-logloss:0.000824 eval-logloss:0.000812
## [84] train-logloss:0.000749 eval-logloss:0.000738
## [85] train-logloss:0.000739 eval-logloss:0.000727
## [86] train-logloss:0.000672 eval-logloss:0.000661
## [87] train-logloss:0.000667 eval-logloss:0.000657
## [88] train-logloss:0.000663 eval-logloss:0.000653
## [89] train-logloss:0.000603 eval-logloss:0.000594
## [90] train-logloss:0.000599 eval-logloss:0.000591
## [91] train-logloss:0.000595 eval-logloss:0.000587
## [92] train-logloss:0.000542 eval-logloss:0.000534
## [93] train-logloss:0.000494 eval-logloss:0.000487
## [94] train-logloss:0.000450 eval-logloss:0.000444
## [95] train-logloss:0.000410 eval-logloss:0.000405
## [96] train-logloss:0.000375 eval-logloss:0.000369
## [97] train-logloss:0.000342 eval-logloss:0.000338
## [98] train-logloss:0.000313 eval-logloss:0.000309
```

```

## [99] train-logloss:0.000287 eval-logloss:0.000283
## [100] train-logloss:0.000282 eval-logloss:0.000278
## [101] train-logloss:0.000259 eval-logloss:0.000255
## [102] train-logloss:0.000237 eval-logloss:0.000234
## [103] train-logloss:0.000218 eval-logloss:0.000215
## [104] train-logloss:0.000216 eval-logloss:0.000213
## [105] train-logloss:0.000212 eval-logloss:0.000210
## [106] train-logloss:0.000211 eval-logloss:0.000209
## [107] train-logloss:0.000208 eval-logloss:0.000205
## [108] train-logloss:0.000191 eval-logloss:0.000189
## [109] train-logloss:0.000176 eval-logloss:0.000174
## [110] train-logloss:0.000174 eval-logloss:0.000172
## [111] train-logloss:0.000171 eval-logloss:0.000170
## [112] train-logloss:0.000158 eval-logloss:0.000156
## [113] train-logloss:0.000146 eval-logloss:0.000145
## [114] train-logloss:0.000135 eval-logloss:0.000134
## [115] train-logloss:0.000125 eval-logloss:0.000124
## [116] train-logloss:0.000116 eval-logloss:0.000115
## [117] train-logloss:0.000108 eval-logloss:0.000107
## [118] train-logloss:0.000100 eval-logloss:0.000099
## [119] train-logloss:0.000100 eval-logloss:0.000099
## [120] train-logloss:0.000093 eval-logloss:0.000092
## [121] train-logloss:0.000087 eval-logloss:0.000086
## [122] train-logloss:0.000081 eval-logloss:0.000081
## [123] train-logloss:0.000080 eval-logloss:0.000080
## [124] train-logloss:0.000075 eval-logloss:0.000075
## [125] train-logloss:0.000071 eval-logloss:0.000070
## [126] train-logloss:0.000066 eval-logloss:0.000066
## [127] train-logloss:0.000066 eval-logloss:0.000065
## [128] train-logloss:0.000062 eval-logloss:0.000062
## [129] train-logloss:0.000058 eval-logloss:0.000058
## [130] train-logloss:0.000055 eval-logloss:0.000055
## [131] train-logloss:0.000055 eval-logloss:0.000055
## [132] train-logloss:0.000055 eval-logloss:0.000054
## [133] train-logloss:0.000052 eval-logloss:0.000051
## [134] train-logloss:0.000051 eval-logloss:0.000051
## [135] train-logloss:0.000049 eval-logloss:0.000048
## [136] train-logloss:0.000049 eval-logloss:0.000048
## [137] train-logloss:0.000048 eval-logloss:0.000048
## [138] train-logloss:0.000048 eval-logloss:0.000048
## [139] train-logloss:0.000048 eval-logloss:0.000048
## [140] train-logloss:0.000048 eval-logloss:0.000048
## [141] train-logloss:0.000047 eval-logloss:0.000047
## [142] train-logloss:0.000047 eval-logloss:0.000047
## [143] train-logloss:0.000047 eval-logloss:0.000047
## [144] train-logloss:0.000047 eval-logloss:0.000047
## [145] train-logloss:0.000047 eval-logloss:0.000047
## [146] train-logloss:0.000047 eval-logloss:0.000047
## [147] train-logloss:0.000047 eval-logloss:0.000046
## [148] train-logloss:0.000047 eval-logloss:0.000046
## [149] train-logloss:0.000047 eval-logloss:0.000046
## [150] train-logloss:0.000046 eval-logloss:0.000046
## [151] train-logloss:0.000046 eval-logloss:0.000046
## [152] train-logloss:0.000046 eval-logloss:0.000046

```



```

## [315] train-logloss:0.000042 eval-logloss:0.000043
## [316] train-logloss:0.000042 eval-logloss:0.000043
## [317] train-logloss:0.000042 eval-logloss:0.000043
## [318] train-logloss:0.000042 eval-logloss:0.000043
## [319] train-logloss:0.000042 eval-logloss:0.000043
## [320] train-logloss:0.000042 eval-logloss:0.000043
## [321] train-logloss:0.000042 eval-logloss:0.000043
## [322] train-logloss:0.000042 eval-logloss:0.000043
## [323] train-logloss:0.000042 eval-logloss:0.000043
## [324] train-logloss:0.000042 eval-logloss:0.000043
## [325] train-logloss:0.000042 eval-logloss:0.000043
## [326] train-logloss:0.000042 eval-logloss:0.000043
## [327] train-logloss:0.000042 eval-logloss:0.000043
## [328] train-logloss:0.000042 eval-logloss:0.000043
## [329] train-logloss:0.000042 eval-logloss:0.000043
## [330] train-logloss:0.000041 eval-logloss:0.000043
## [331] train-logloss:0.000041 eval-logloss:0.000043
## [332] train-logloss:0.000041 eval-logloss:0.000043
## [333] train-logloss:0.000041 eval-logloss:0.000043
## [334] train-logloss:0.000041 eval-logloss:0.000043
## [335] train-logloss:0.000041 eval-logloss:0.000043
## [336] train-logloss:0.000041 eval-logloss:0.000043
## [337] train-logloss:0.000041 eval-logloss:0.000043
## [338] train-logloss:0.000041 eval-logloss:0.000043
## [339] train-logloss:0.000041 eval-logloss:0.000043
## [340] train-logloss:0.000041 eval-logloss:0.000043
## [341] train-logloss:0.000041 eval-logloss:0.000043
## [342] train-logloss:0.000041 eval-logloss:0.000043
## [343] train-logloss:0.000041 eval-logloss:0.000043
## [344] train-logloss:0.000041 eval-logloss:0.000043
## [345] train-logloss:0.000041 eval-logloss:0.000043
## [346] train-logloss:0.000041 eval-logloss:0.000043
## [347] train-logloss:0.000041 eval-logloss:0.000043
## [348] train-logloss:0.000041 eval-logloss:0.000043
## [349] train-logloss:0.000041 eval-logloss:0.000043
## [350] train-logloss:0.000041 eval-logloss:0.000043
## [351] train-logloss:0.000041 eval-logloss:0.000043
## [352] train-logloss:0.000041 eval-logloss:0.000043
## [353] train-logloss:0.000041 eval-logloss:0.000043
## [354] train-logloss:0.000041 eval-logloss:0.000043
## [355] train-logloss:0.000041 eval-logloss:0.000043
## [356] train-logloss:0.000041 eval-logloss:0.000043

## Stopping. Best iteration:
## [346] train-logloss:0.000041 eval-logloss:0.000043
##
## [1] train-logloss:0.598164 eval-logloss:0.598171
## Multiple eval metrics are present. Will use eval_logloss for early stopping.
## Will train until eval_logloss hasn't improved in 10 rounds.
##
## [2] train-logloss:0.522076 eval-logloss:0.522023
## [3] train-logloss:0.456924 eval-logloss:0.456884
## [4] train-logloss:0.401868 eval-logloss:0.401839
## [5] train-logloss:0.354844 eval-logloss:0.354818
## [6] train-logloss:0.314347 eval-logloss:0.314330

```

```
## [7] train-logloss:0.279981 eval-logloss:0.279938
## [8] train-logloss:0.250027 eval-logloss:0.249966
## [9] train-logloss:0.223008 eval-logloss:0.222959
## [10] train-logloss:0.199245 eval-logloss:0.199207
## [11] train-logloss:0.178273 eval-logloss:0.178238
## [12] train-logloss:0.168035 eval-logloss:0.168023
## [13] train-logloss:0.150623 eval-logloss:0.150613
## [14] train-logloss:0.135154 eval-logloss:0.135146
## [15] train-logloss:0.121386 eval-logloss:0.121384
## [16] train-logloss:0.114251 eval-logloss:0.114267
## [17] train-logloss:0.102728 eval-logloss:0.102743
## [18] train-logloss:0.092429 eval-logloss:0.092444
## [19] train-logloss:0.083504 eval-logloss:0.083509
## [20] train-logloss:0.075216 eval-logloss:0.075225
## [21] train-logloss:0.067784 eval-logloss:0.067796
## [22] train-logloss:0.061113 eval-logloss:0.061128
## [23] train-logloss:0.055424 eval-logloss:0.055439
## [24] train-logloss:0.050001 eval-logloss:0.050015
## [25] train-logloss:0.045462 eval-logloss:0.045472
## [26] train-logloss:0.042082 eval-logloss:0.042105
## [27] train-logloss:0.038201 eval-logloss:0.038218
## [28] train-logloss:0.034494 eval-logloss:0.034510
## [29] train-logloss:0.031157 eval-logloss:0.031174
## [30] train-logloss:0.028145 eval-logloss:0.028162
## [31] train-logloss:0.025430 eval-logloss:0.025445
## [32] train-logloss:0.022983 eval-logloss:0.022999
## [33] train-logloss:0.020775 eval-logloss:0.020793
## [34] train-logloss:0.019826 eval-logloss:0.019846
## [35] train-logloss:0.017923 eval-logloss:0.017940
## [36] train-logloss:0.016204 eval-logloss:0.016220
## [37] train-logloss:0.014810 eval-logloss:0.014823
## [38] train-logloss:0.013395 eval-logloss:0.013409
## [39] train-logloss:0.012238 eval-logloss:0.012254
## [40] train-logloss:0.011071 eval-logloss:0.011088
## [41] train-logloss:0.010014 eval-logloss:0.010030
## [42] train-logloss:0.009059 eval-logloss:0.009074
## [43] train-logloss:0.008280 eval-logloss:0.008295
## [44] train-logloss:0.007610 eval-logloss:0.007625
## [45] train-logloss:0.007356 eval-logloss:0.007372
## [46] train-logloss:0.006657 eval-logloss:0.006671
## [47] train-logloss:0.006026 eval-logloss:0.006042
## [48] train-logloss:0.005456 eval-logloss:0.005473
## [49] train-logloss:0.004941 eval-logloss:0.004959
## [50] train-logloss:0.004686 eval-logloss:0.004705
## [51] train-logloss:0.004245 eval-logloss:0.004265
## [52] train-logloss:0.003907 eval-logloss:0.003926
## [53] train-logloss:0.003730 eval-logloss:0.003751
## [54] train-logloss:0.003445 eval-logloss:0.003463
## [55] train-logloss:0.003200 eval-logloss:0.003220
## [56] train-logloss:0.003129 eval-logloss:0.003150
## [57] train-logloss:0.002836 eval-logloss:0.002858
## [58] train-logloss:0.002782 eval-logloss:0.002806
## [59] train-logloss:0.002520 eval-logloss:0.002542
## [60] train-logloss:0.002283 eval-logloss:0.002303
```

```

## [61] train-logloss:0.002069 eval-logloss:0.002087
## [62] train-logloss:0.001876 eval-logloss:0.001892
## [63] train-logloss:0.001811 eval-logloss:0.001829
## [64] train-logloss:0.001644 eval-logloss:0.001662
## [65] train-logloss:0.001537 eval-logloss:0.001556
## [66] train-logloss:0.001394 eval-logloss:0.001412
## [67] train-logloss:0.001264 eval-logloss:0.001281
## [68] train-logloss:0.001152 eval-logloss:0.001169
## [69] train-logloss:0.001137 eval-logloss:0.001154
## [70] train-logloss:0.001124 eval-logloss:0.001142
## [71] train-logloss:0.001026 eval-logloss:0.001043
## [72] train-logloss:0.000937 eval-logloss:0.000953
## [73] train-logloss:0.000857 eval-logloss:0.000872
## [74] train-logloss:0.000806 eval-logloss:0.000821
## [75] train-logloss:0.000738 eval-logloss:0.000753
## [76] train-logloss:0.000675 eval-logloss:0.000689
## [77] train-logloss:0.000615 eval-logloss:0.000627
## [78] train-logloss:0.000560 eval-logloss:0.000571
## [79] train-logloss:0.000555 eval-logloss:0.000567
## [80] train-logloss:0.000528 eval-logloss:0.000540
## [81] train-logloss:0.000504 eval-logloss:0.000516
## [82] train-logloss:0.000460 eval-logloss:0.000470
## [83] train-logloss:0.000437 eval-logloss:0.000449
## [84] train-logloss:0.000417 eval-logloss:0.000429
## [85] train-logloss:0.000381 eval-logloss:0.000392
## [86] train-logloss:0.000348 eval-logloss:0.000358
## [87] train-logloss:0.000318 eval-logloss:0.000328
## [88] train-logloss:0.000291 eval-logloss:0.000300
## [89] train-logloss:0.000267 eval-logloss:0.000275
## [90] train-logloss:0.000264 eval-logloss:0.000272
## [91] train-logloss:0.000262 eval-logloss:0.000270
## [92] train-logloss:0.000240 eval-logloss:0.000248
## [93] train-logloss:0.000232 eval-logloss:0.000241
## [94] train-logloss:0.000214 eval-logloss:0.000221
## [95] train-logloss:0.000196 eval-logloss:0.000204
## [96] train-logloss:0.000181 eval-logloss:0.000187
## [97] train-logloss:0.000167 eval-logloss:0.000173
## [98] train-logloss:0.000163 eval-logloss:0.000169
## [99] train-logloss:0.000150 eval-logloss:0.000156
## [100] train-logloss:0.000139 eval-logloss:0.000144
## [101] train-logloss:0.000129 eval-logloss:0.000134
## [102] train-logloss:0.000119 eval-logloss:0.000124
## [103] train-logloss:0.000111 eval-logloss:0.000115
## [104] train-logloss:0.000103 eval-logloss:0.000107
## [105] train-logloss:0.000096 eval-logloss:0.000100
## [106] train-logloss:0.000090 eval-logloss:0.000093
## [107] train-logloss:0.000088 eval-logloss:0.000092
## [108] train-logloss:0.000086 eval-logloss:0.000090
## [109] train-logloss:0.000081 eval-logloss:0.000084
## [110] train-logloss:0.000075 eval-logloss:0.000079
## [111] train-logloss:0.000075 eval-logloss:0.000079
## [112] train-logloss:0.000070 eval-logloss:0.000074
## [113] train-logloss:0.000066 eval-logloss:0.000069
## [114] train-logloss:0.000065 eval-logloss:0.000068

```



```

## [331] train-logloss:0.000041 eval-logloss:0.000046
## [332] train-logloss:0.000041 eval-logloss:0.000046
## [333] train-logloss:0.000041 eval-logloss:0.000046
## [334] train-logloss:0.000041 eval-logloss:0.000046
## [335] train-logloss:0.000041 eval-logloss:0.000046
## [336] train-logloss:0.000041 eval-logloss:0.000046
## [337] train-logloss:0.000041 eval-logloss:0.000046
## [338] train-logloss:0.000041 eval-logloss:0.000046
## [339] train-logloss:0.000041 eval-logloss:0.000046
## [340] train-logloss:0.000041 eval-logloss:0.000046
## [341] train-logloss:0.000041 eval-logloss:0.000046
## [342] train-logloss:0.000041 eval-logloss:0.000046
## [343] train-logloss:0.000041 eval-logloss:0.000046
## [344] train-logloss:0.000041 eval-logloss:0.000046
## [345] train-logloss:0.000041 eval-logloss:0.000046
## [346] train-logloss:0.000041 eval-logloss:0.000046
## [347] train-logloss:0.000041 eval-logloss:0.000046
## [348] train-logloss:0.000041 eval-logloss:0.000046
## [349] train-logloss:0.000041 eval-logloss:0.000046
## [350] train-logloss:0.000041 eval-logloss:0.000046
## [351] train-logloss:0.000040 eval-logloss:0.000046
## [352] train-logloss:0.000040 eval-logloss:0.000046
## [353] train-logloss:0.000040 eval-logloss:0.000046
## [354] train-logloss:0.000040 eval-logloss:0.000046
## [355] train-logloss:0.000040 eval-logloss:0.000046
## [356] train-logloss:0.000040 eval-logloss:0.000046
## [357] train-logloss:0.000040 eval-logloss:0.000046
## [358] train-logloss:0.000040 eval-logloss:0.000046
## Stopping. Best iteration:
## [348] train-logloss:0.000041 eval-logloss:0.000046

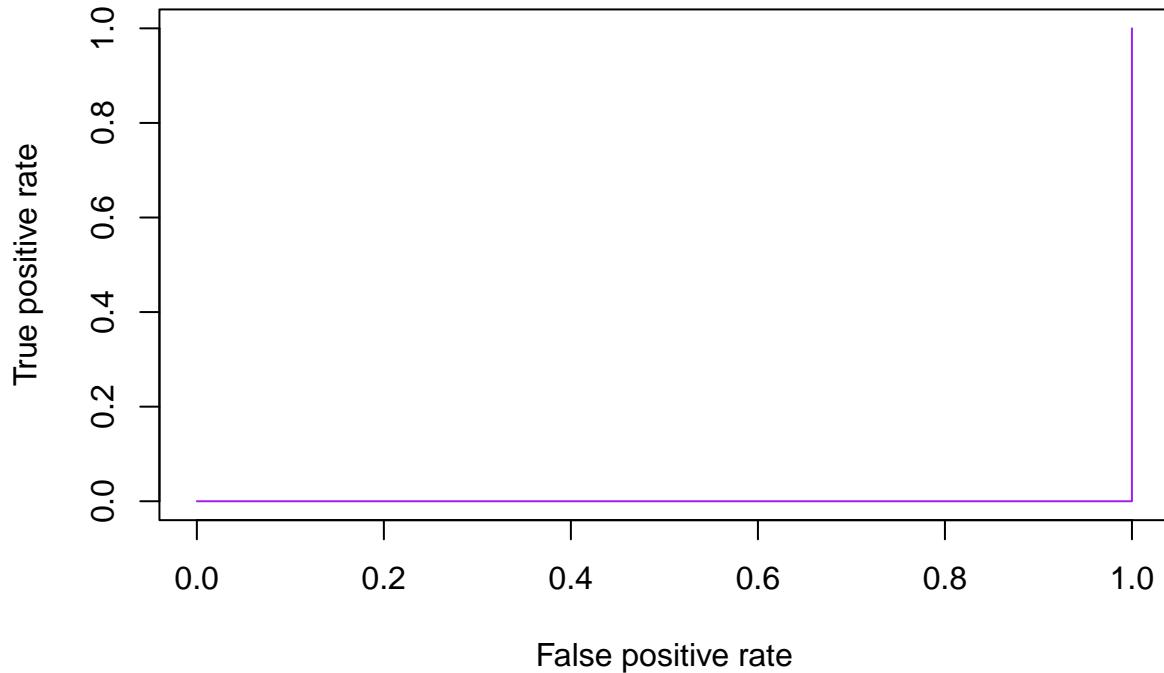
```

#The AUC value for XG Boost is 0.68, this model performs as well as the rpart decision tree model.

```

# ROC Curve
perfRoc_xgbTst=aucPerf_xgb_lsM1
plot(perfRoc_xgbTst,col='purple')

```



7th question

```
#Cost Analysis
temp <- read_csv("/Users/nithin/Documents/Data mining/lcDataSampleFall122.csv",show_col_types = FALSE )

## Warning: One or more parsing issues, see 'problems()' for details

temp <- temp %>% filter(loan_status == "Fully Paid" | loan_status == "Charged Off")
dim(temp)

## [1] 100000     145

temp<- temp %>% select_if(function(x){!all(is.na(x))})
names(temp)[colSums(is.na(temp))>0]

## [1] "emp_title"                  "title"
## [3] "mths_since_last_delinq"    "mths_since_last_record"
## [5] "revol_util"                "last_pymnt_d"
## [7] "last_credit_pull_d"         "mths_since_last_major_derog"
## [9] "open_acc_6m"                "open_act_il"
```

```

## [11] "open_il_12m"
## [13] "mths_since_rcnt_il"
## [15] "il_util"
## [17] "open_rv_24m"
## [19] "all_util"
## [21] "total_cu_tl"
## [23] "avg_cur_bal"
## [25] "bc_util"
## [27] "mths_since_recent_bc"
## [29] "mths_since_recent_inq"
## [31] "num_rev_accts"
## [33] "pct_tl_nvr_dlq"
## [35] "hardship_dpd"
## [36] "inq_fi"
## [37] "inq_last_12m"
## [38] "bc_open_to_buy"
## [39] "mo_sin_old_il_acct"
## [40] "mths_since_recent_bc_dlq"
## [41] "mths_since_recent_revol_delinq"
## [42] "num_tl_120dpd_2m"
## [43] "percent_bc_gt_75"
## [44] "settlement_term"

```

```
colMeans(is.na(temp))
```

##	loan_amnt	funded_amnt
##	0.00000	0.00000
##	funded_amnt_inv	term
##	0.00000	0.00000
##	int_rate	installment
##	0.00000	0.00000
##	grade	sub_grade
##	0.00000	0.00000
##	emp_title	emp_length
##	0.06705	0.00000
##	home_ownership	annual_inc
##	0.00000	0.00000
##	verification_status	issue_d
##	0.00000	0.00000
##	loan_status	pymnt_plan
##	0.00000	0.00000
##	purpose	title
##	0.00000	0.00012
##	zip_code	addr_state
##	0.00000	0.00000
##	dti	delinq_2yrs
##	0.00000	0.00000
##	earliest_cr_line	inq_last_6mths
##	0.00000	0.00000
##	mths_since_last_delinq	mths_since_last_record
##	0.49919	0.82423
##	open_acc	pub_rec
##	0.00000	0.00000
##	revol_bal	revol_util
##	0.00000	0.00041
##	total_acc	initial_list_status
##	0.00000	0.00000
##	out_prncp	out_prncp_inv
##	0.00000	0.00000
##	total_pymnt	total_pymnt_inv
##	0.00000	0.00000
##	total_rec_prncp	total_rec_int
##	0.00000	0.00000

```

##          total_rec_late_fee                      recoveries
##                           0.00000                     0.00000
##          collection_recovery_fee                  last_pymnt_d
##                           0.00000                     0.00064
##          last_pymnt_amnt                      last_credit_pull_d
##                           0.00000                     0.00004
##          collections_12_mths_ex_med            mths_since_last_major_derog
##                           0.00000                     0.71995
##          policy_code                         application_type
##                           0.00000                     0.00000
##          acc_now_delinq                      tot_coll_amt
##                           0.00000                     0.00000
##          tot_cur_bal                         open_acc_6m
##                           0.00000                     0.97313
##          open_act_il                          open_il_12m
##                           0.97313                     0.97313
##          open_il_24m                         mths_since_rcnt_il
##                           0.97313                     0.97393
##          total_bal_il                         il_util
##                           0.97313                     0.97694
##          open_rv_12m                          open_rv_24m
##                           0.97313                     0.97313
##          max_bal_bc                           all_util
##                           0.97313                     0.97313
##          total_rev_hi_lim                    inq_fi
##                           0.00000                     0.97313
##          total_cu_tl                          inq_last_12m
##                           0.97313                     0.97313
##          acc_open_past_24mths                 avg_cur_bal
##                           0.00000                     0.00002
##          bc_open_to_buy                      bc_util
##                           0.00964                     0.01044
##          chargeoff_within_12_mths            delinq_amnt
##                           0.00000                     0.00000
##          mo_sin_old_il_acct                  mo_sin_old_rev_tl_op
##                           0.03620                     0.00000
##          mo_sin_rcnt_rev_tl_op              mo_sin_rcnt_tl
##                           0.00000                     0.00000
##          mort_acc                            mths_since_recent_bc
##                           0.00000                     0.00911
##          mths_since_recent_bc_dlq            mths_since_recent_inq
##                           0.74329                     0.10612
##          mths_since_recent_revol_delinq      num_accts_ever_120_pd
##                           0.64746                     0.00000
##          num_actv_bc_tl                      num_actv_rev_tl
##                           0.00000                     0.00000
##          num_bc_sats                         num_bc_tl
##                           0.00000                     0.00000
##          num_il_tl                           num_op_rev_tl
##                           0.00000                     0.00000
##          num_rev_accts                      num_rev_tl_bal_gt_0
##                           0.00001                     0.00000
##          num_sats                            num_tl_120dpd_2m
##                           0.00000                     0.03824

```

```

##          num_tl_30dpd      num_tl_90g_dpd_24m
##                  0.00000          0.00000
##          num_tl_op_past_12m    pct_tl_nvr_dlq
##                  0.00000          0.00016
##          percent_bc_gt_75      pub_rec_bankruptcies
##                  0.01034          0.00000
##          tax_liens           tot_hi_cred_lim
##                  0.00000          0.00000
##          total_bal_ex_mort     total_bc_limit
##                  0.00000          0.00000
##          total_il_high_credit_limit hardship_flag
##                  0.00000          0.00000
##          hardship_dpd         disbursement_method
##                  0.99955          0.00000
##          debt_settlement_flag   settlement_term
##                  0.00000          0.99535

```

```
colMeans(is.na(temp))[colMeans(is.na(temp))>0]
```

```

##          emp_title          title
##                  0.06705          0.00012
##          mths_since_last_delinq mths_since_last_record
##                  0.49919          0.82423
##          revol_util          last_pymnt_d
##                  0.00041          0.00064
##          last_credit_pull_d    mths_since_last_major_derog
##                  0.00004          0.71995
##          open_acc_6m          open_act_il
##                  0.97313          0.97313
##          open_il_12m          open_il_24m
##                  0.97313          0.97313
##          mths_since_rcnt_il    total_bal_il
##                  0.97393          0.97313
##          il_util              open_rv_12m
##                  0.97694          0.97313
##          open_rv_24m          max_bal_bc
##                  0.97313          0.97313
##          all_util              inq_fi
##                  0.97313          0.97313
##          total_cu_tl          inq_last_12m
##                  0.97313          0.97313
##          avg_cur_bal          bc_open_to_buy
##                  0.00002          0.00964
##          bc_util              mo_sin_old_il_acct
##                  0.01044          0.03620
##          mths_since_recent_bc   mths_since_recent_bc_dlq
##                  0.00911          0.74329
##          mths_since_recent_inq  mths_since_recent_revol_delinq
##                  0.10612          0.64746
##          num_rev_accts          num_tl_120dpd_2m
##                  0.00001          0.03824
##          pct_tl_nvr_dlq         percent_bc_gt_75
##                  0.00016          0.01034
##          hardship_dpd          settlement_term

```

```

##                               0.99955                               0.99535

nm<-names(temp)[colMeans(is.na(temp))>0.6]
temp <- temp %>% select(-nm)

## Note: Using an external vector in selections is ambiguous.
## i Use 'all_of(nm)' instead of 'nm' to silence this message.
## i See <https://tidyselect.r-lib.org/reference/faq-external-vector.html>.
## This message is displayed once per session.

colMeans(is.na(temp))[colMeans(is.na(temp))>0]

##          emp_title           title      mths_since_last_delinq
##          0.06705          0.00012          0.49919
##          revol_util      last_pymnt_d    last_credit_pull_d
##          0.00041          0.00064          0.00004
##          avg_cur_bal     bc_open_to_buy   bc_util
##          0.00002          0.00964          0.01044
##          mo_sin_old_il_acct mths_since_recent_bc mths_since_recent_inq
##          0.03620          0.00911          0.10612
##          num_rev_accts    num_tl_120dpd_2m   pct_tl_nvr_dlq
##          0.00001          0.03824          0.00016
##          percent_bc_gt_75
##          0.01034

nm<- names(temp)[colSums(is.na(temp))>0]
summary(temp[, nm])

##   emp_title           title      mths_since_last_delinq      revol_util
##   Length:100000      Length:100000      Min.   : 0.00      Min.   : 0.00
##   Class :character   Class :character   1st Qu.: 15.00    1st Qu.: 36.20
##   Mode  :character   Mode  :character   Median : 31.00    Median : 54.10
##                                     Mean   : 33.94    Mean   : 53.75
##                                     3rd Qu.: 50.00    3rd Qu.: 71.80
##                                     Max.  :188.00    Max.  :153.70
##                                     NA's   :49919     NA's   :41
##   last_pymnt_d      last_credit_pull_d avg_cur_bal      bc_open_to_buy
##   Length:100000      Length:100000      Min.   : 0       Min.   : 0
##   Class :character   Class :character   1st Qu.: 2791    1st Qu.: 1203
##   Mode  :character   Mode  :character   Median : 6312    Median : 3893
##                                     Mean   : 12470   Mean   : 9046
##                                     3rd Qu.: 17267   3rd Qu.: 10602
##                                     Max.  :395953   Max.  :332178
##                                     NA's   :2       NA's   :964
##   bc_util           mo_sin_old_il_acct mths_since_recent_bc mths_since_recent_inq
##   Min.   : 0.00      Min.   : 0       Min.   : 0.0       Min.   : 0.000
##   1st Qu.: 42.30    1st Qu.: 96      1st Qu.: 6.0       1st Qu.: 2.000
##   Median : 66.20    Median :128      Median : 14.0      Median : 5.000
##   Mean   : 62.45    Mean   :125      Mean   : 24.5      Mean   : 6.908
##   3rd Qu.: 86.20    3rd Qu.:152      3rd Qu.: 29.0      3rd Qu.:10.000
##   Max.  :188.80    Max.  :640      Max.  :616.0      Max.  :24.000
##   NA's   :1044      NA's   :3620     NA's   :911       NA's   :10612

```

```

##  num_rev_accts  num_tl_120dpd_2m pct_tl_nvr_dlq  percent_bc_gt_75
##  Min.    : 2.00  Min.    :0.000   Min.    : 20.00  Min.    :  0.00
##  1st Qu.: 9.00  1st Qu.:0.000   1st Qu.: 91.00  1st Qu.: 16.70
##  Median  :13.00  Median  :0.000   Median  : 97.80  Median  : 50.00
##  Mean    :14.76  Mean    :0.001   Mean    : 94.05  Mean    : 48.03
##  3rd Qu.:19.00  3rd Qu.:0.000   3rd Qu.:100.00  3rd Qu.: 75.00
##  Max.    :87.00  Max.    :2.000   Max.    :100.00  Max.    :100.00
##  NA's    :1       NA's    :3824    NA's    :16      NA's    :1034

temp<- temp%>% replace_na(list(mths_since_last_delinq=500, revol_util=median(temp$revol_util, na.rm=TRUE)
colMeans(is.na(temp))[colMeans(is.na(temp))>0]

##          emp_title           title      last_pymnt_d last_credit_pull_d
##          0.06705        0.00012        0.00064        0.00004
##          avg_cur_bal     num_rev_accts  pct_tl_nvr_dlq
##          0.00002        0.00001        0.00016

temp$last_pymnt_d<-paste(temp$last_pymnt_d, "-01", sep = "")
temp$last_pymnt_d<-parse_date_time(temp$last_pymnt_d, "myd")

## Warning: 64 failed to parse.

x<- as.duration(temp$issue_d  %--% temp$last_pymnt_d)
head(x)

## [1] "36892800s (~1.17 years)" "60566400s (~1.92 years)"
## [3] "94694400s (~3 years)"    "44755200s (~1.42 years)"
## [5] "81648000s (~2.59 years)" "68256000s (~2.16 years)"

x<- as.duration(temp$issue_d  %--% temp$last_pymnt_d)/dweeks(1)
yearsx<- as.duration(temp$issue_d  %--% temp$last_pymnt_d)/dyears(1)

temp$actualTerm <- ifelse(temp$loan_status=="Fully Paid", as.duration(temp$issue_d  %--% temp$last_pymnt_d))
temp$actualReturn <- ifelse(temp$actualTerm>0, ((temp$total_pymnt -temp$funded_amnt)/temp$funded_amnt)*
temp%>% group_by(loan_status) %>% summarise(avgInt=mean(int_rate), avgActInt = mean(actualReturn))

## # A tibble: 2 x 3
##   loan_status avgInt avgActInt
##   <chr>        <dbl>     <dbl>
## 1 Charged Off    13.9     -12.0
## 2 Fully Paid     11.7      8.02

PROFITVAL <- 24 #profit (on $100) from accurately identifying Fully_paid loans
COSTVAL <- -35 # loss (on $100) from incorrectly predicting a Charged_Off loan as Full_paid

temp %>% group_by(loan_status) %>% summarise(avgInt=mean(int_rate), avgRet=mean(actualReturn),
avgTerm=mean(actualTerm))

```

```

## # A tibble: 2 x 4
##   loan_status avgInt avgRet avgTerm
##   <chr>        <dbl>  <dbl>    <dbl>
## 1 Charged Off    13.9 -12.0      3
## 2 Fully Paid     11.7   8.02   2.13

TRNFRACTION = 0.7
#Doing a 70-30 split between training and test subsets
num_row<-nrow(temp)

trn<- sample(1:num_row, size = round(TRNFRACTION * num_row), replace=FALSE)
lcdfTrn2 <- temp[trn, ]
lcdfTst2 <- temp[-trn, ]

#Random forest Model - num.trees=50 and importance=permutation
rf <- ranger(as.factor(loan_status) ~., data=subset(lcdfTrn2, select=-c(actualTerm, actualReturn, total...
rfPredictions <- predict(rf, lcdfTst2)$predictions
scoreRF <- rfPredictions[, "Fully Paid"]
prPerfRF <- data.frame(scoreRF)
prRetPerfRF <- cbind(prPerfRF, status=lcdfTst2$loan_status, grade=lcdfTst2$grade, actRet=lcdfTst2$actual...
prRetPerfRF <- prRetPerfRF %>% mutate(decile = ntile(-scoreRF, 10))
view(prRetPerfRF)
prRetPerfRF %>% group_by(decile) %>% summarise(count=n(), numDefaults=sum(status=="Charged Off"), avgAc...
minRet=min(actRet), maxRet=max(actRet), avgTer=mean(actTerm), totA=sum(grade=="A"), totB=sum(grade=="B...
totD=sum(grade=="D"), totE=sum(grade=="E"), totF=sum(grade=="F"))

## # A tibble: 10 x 13
##   decile count numDefaults avgAc~1 minRet maxRet avgTer  totA  totB  totC  totD
##   <int> <int>       <int>    <dbl>  <dbl>  <dbl> <dbl> <int> <int> <int> <int>
## 1 1     1  3000          0    8.28    0    28.9  1.80  858  1156  681  256
## 2 2     2  3000          0    8.23    0    40.2  1.78  877  1170  679  229
## 3 3     3  3000          1    8.20    0    28.5  1.80  915  1141  656  236
## 4 4     4  3000          2    8.12    0    30.9  1.91  877  1120  667  284
## 5 5     5  3000          1    7.70    0    33.6  2.22  831  1069  744  275
## 6 6     6  3000          4    7.77    0    40.8  2.29  744  1065  754  341
## 7 7     7  3000          1    8.00    0    31.3  2.31  634  983  829  412
## 8 8     8  3000          9    7.79  -1.69   29.5  2.56  514  894  922  462
## 9 9     9  3000        1093   1.27 -33.3   25.3  2.76  392  745  945  600
## 10 10  10  3000        3000  -12.3  -32.2   13.7  3    206  793  1047  656
## # ... with 2 more variables: totE <int>, totF <int>, and abbreviated variable
## #   name 1: avgActRet

#Performance
prPerfRF2 <- cbind(prPerfRF, status=lcdfTst2$loan_status)
prPerfRF2 <- prPerfRF2[order(-scoreRF) ,]
prPerfRF2$profit <- ifelse(prPerfRF2$status == 'Fully Paid', PROFITVAL, COSTVAL)
prPerfRF2$cumProfit <- cumsum(prPerfRF2$profit)
view(prPerfRF2)
max(prPerfRF2$cumProfit)

## [1] 617132

```

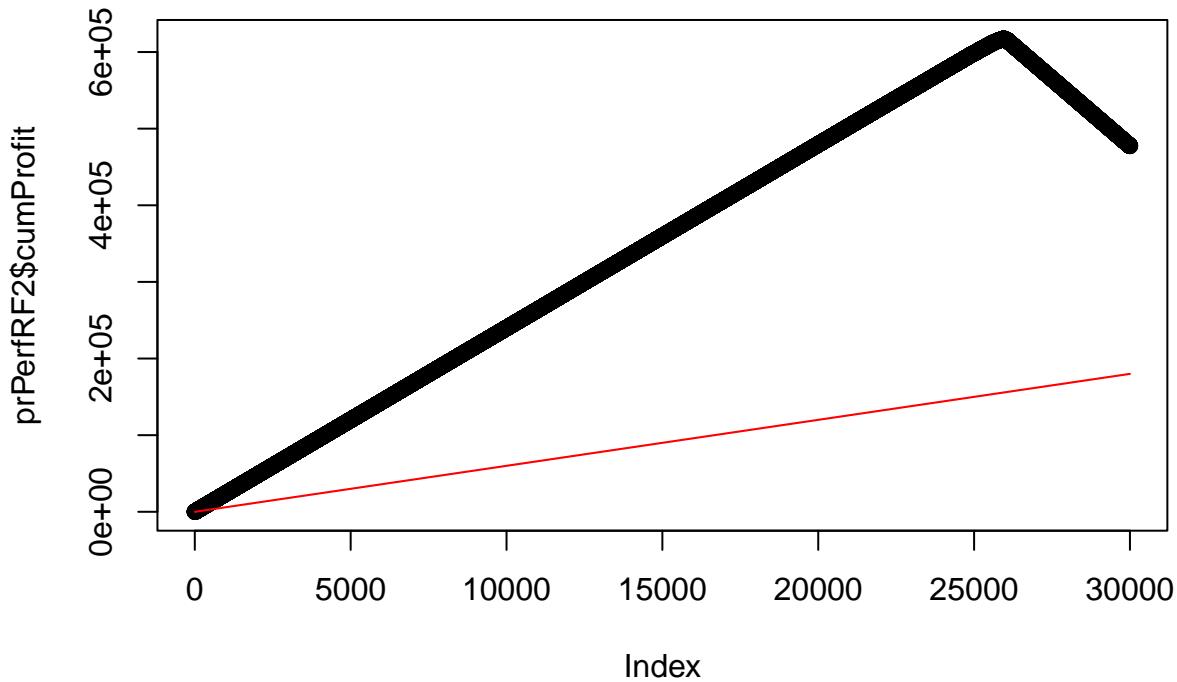
```

which.max(prPerfRF2$cumProfit)

## [1] 25940

plot(prPerfRF2$cumProfit)
#to compare against the default approach of investing in CD with 2% int
# (ie. $6 profit out of $100 in 3 years)
prPerfRF2$cdRet <- 6
prPerfRF2$cumCDRet<- cumsum(prPerfRF2$cdRet)
plot(prPerfRF2$cumProfit)
lines(prPerfRF2$cumCDRet, col='red')

```



```

TRNFRACTION = 0.7
#Doing a 70-30 split between training and test subsets
num_row<-nrow(temp)

trn<- sample(1:num_row, size = round(TRNFRACTION * num_row), replace=FALSE)
lcdfTrn2 <- temp[trn, ]
lcdfTst2 <- temp[-trn, ]
vasr <- c('emp_title','title','zip_code','earliest_cr_line','last_credit_pull_d')
lcdfTrn2 <- lcdfTrn2 %>% select(-all_of(vasr))
lcdfTst2 <- lcdfTst2 %>% select(-all_of(vasr))

#Using R-part decision tree

```

```

rf <- rpart(loan_status ~ ., data=lcdfTrn2, method="class", parms = list(split = "gini"), control=rpart.control(maxdepth=3))
rfPredictions <- predict(rf, lcdfTst2)
scoreRF <- rfPredictions[, "Fully Paid"]
prPerfRF <- data.frame(scoreRF)
prRetPerfRF <- cbind(prPerfRF, status=lcdfTst2$loan_status, grade=lcdfTst2$grade, actRet=lcdfTst2$actualReturn)
prRetPerfRF <- prRetPerfRF %>% mutate(decile = ntile(-scoreRF, 10))
view(prRetPerfRF)
prRetPerfRF %>% group_by(decile) %>% summarise(count=n(), numDefaults=sum(status=="Charged Off"), avgAc=mean(acctTerm), minRet=min(actRet), maxRet=max(actRet), avgTer=mean(actTerm), totA=sum(grade=="A"), totB=sum(grade=="B"), totD=sum(grade=="D"), totE=sum(grade=="E"), totF=sum(grade=="F"))
## # A tibble: 10 x 13
##   decile count numDefaults avgAc~1 minRet maxRet avgTer totA totB totC totD
##   <int> <int>      <int>    <dbl>  <dbl>  <dbl> <dbl> <int> <int> <int> <int>
## 1     1     1     3000        0    7.97    0     27.5  2.14    718  1081   793   315
## 2     2     2     3000        0    8.02    0     29.5  2.14    775  1014   767   319
## 3     3     3     3000        0    8.05    0     28.9  2.14    733  1055   742   347
## 4     4     4     3000        0    8.12    0     26.6  2.13    720  1032   768   362
## 5     5     5     3000        0    7.97    0     28.6  2.11    743  1115   726   316
## 6     6     6     3000        0    8.06    0     30.6  2.13    742  1047   761   336
## 7     7     7     3000        0    7.97    0     24.3  2.14    742  1074   740   335
## 8     8     8     3000        0    8.10    0     30.9  2.11    742  1029   758   349
## 9     9     9     3000     1116  0.218  -33.3    29.6  2.47    579  943   884   422
## 10   10    10     3000    3000  -11.4   -33.3   12.3    3     262  820   997   624
## # ... with 2 more variables: totE <int>, totF <int>, and abbreviated variable
## #   name 1: avgActRet

#Performance
prPerfRF3 <- cbind(prPerfRF, status=lcdfTst2$loan_status)
prPerfRF3 <- prPerfRF2[order(-scoreRF),]
prPerfRF3$profit <- ifelse(prPerfRF3$status == 'Fully Paid', PROFITVAL, COSTVAL)
prPerfRF3$cumProfit <- cumsum(prPerfRF3$profit)
view(prPerfRF3)
max(prPerfRF3$cumProfit)

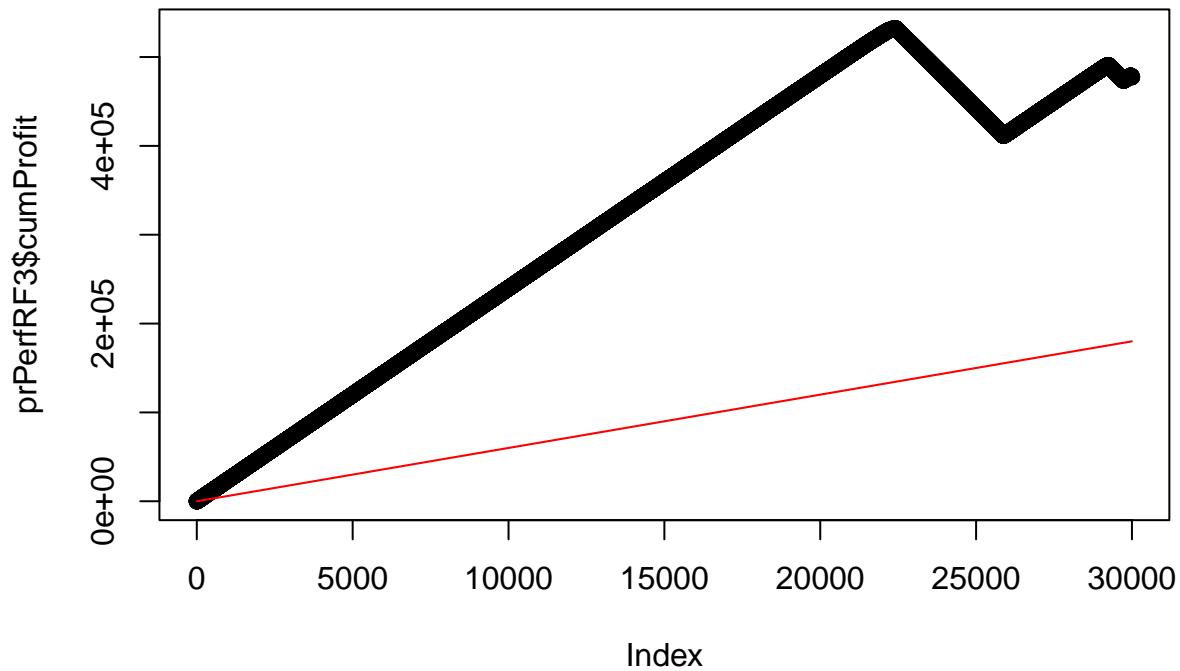
## [1] 532291

which.max(prPerfRF3$cumProfit)

## [1] 22373

plot(prPerfRF3$cumProfit)
#to compare against the default approach of investing in CD with 2% int
# (ie. $6 profit out of $100 in 3 years)
prPerfRF3$cdRet <- 6
prPerfRF3$cumCDRet <- cumsum(prPerfRF3$cdRet)
plot(prPerfRF3$cumProfit)
lines(prPerfRF3$cumCDRet, col='red')

```



#8 Develop models to identify loans which provide the best returns. Explain how you define returns? Does it include Lending Club's service costs? #Develop glm, rf, gbm (xgb) models for this. Show how you systematically experiment with different parameters to find the best models. Compare model performance.

```

TRNFRACTION = 0.7
#Doing a 70-30 split between training and test subsets
num_row<-nrow(temp)

trn<- sample(1:num_row, size = round(TRNFRACTION * num_row), replace=FALSE)
lcdfTrn3 <- df_final[trn, ]
lcdfTst3 <- df_final[-trn, ]

rfModel_Ret <- ranger(actual_return ~., data=subset(lcdfTrn3, select=-c(actual_term, loan_status, last_p
importance='permutation')

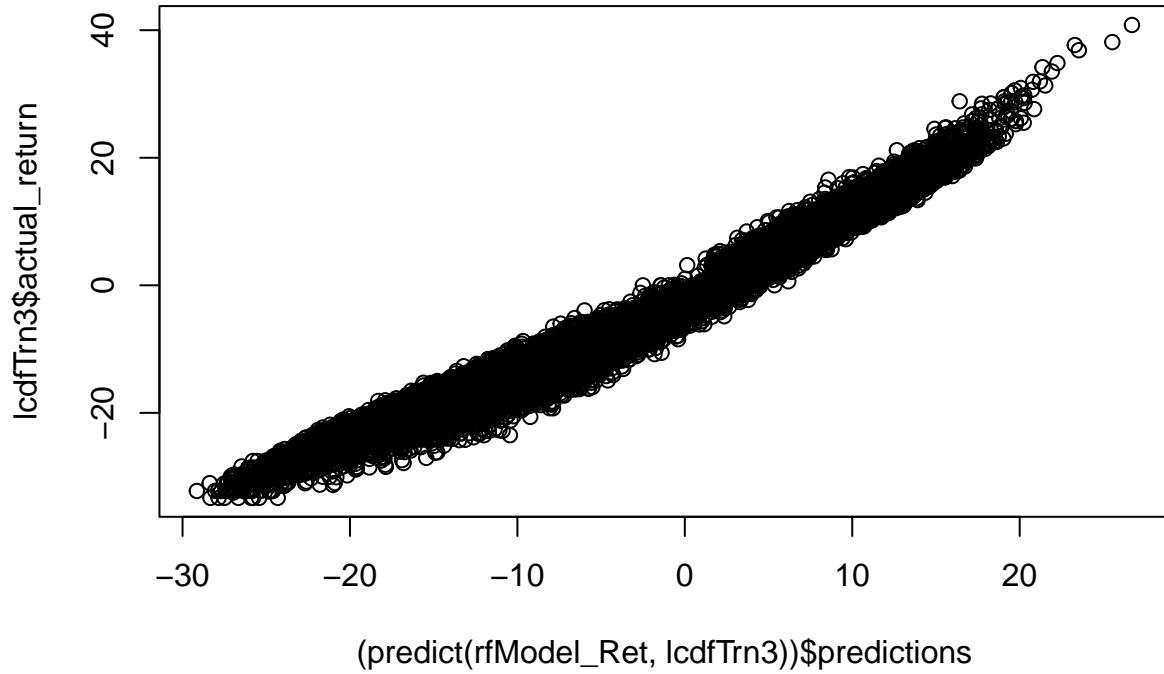
## Computing permutation importance.. Progress: 45%. Estimated remaining time: 39 seconds.
## Computing permutation importance.. Progress: 88%. Estimated remaining time: 8 seconds.

rfPredRet_trn<- predict(rfModel_Ret, lcdfTrn3)
sqrt( mean( (rfPredRet_trn$predictions - lcdfTrn3$actual_return)^2) )

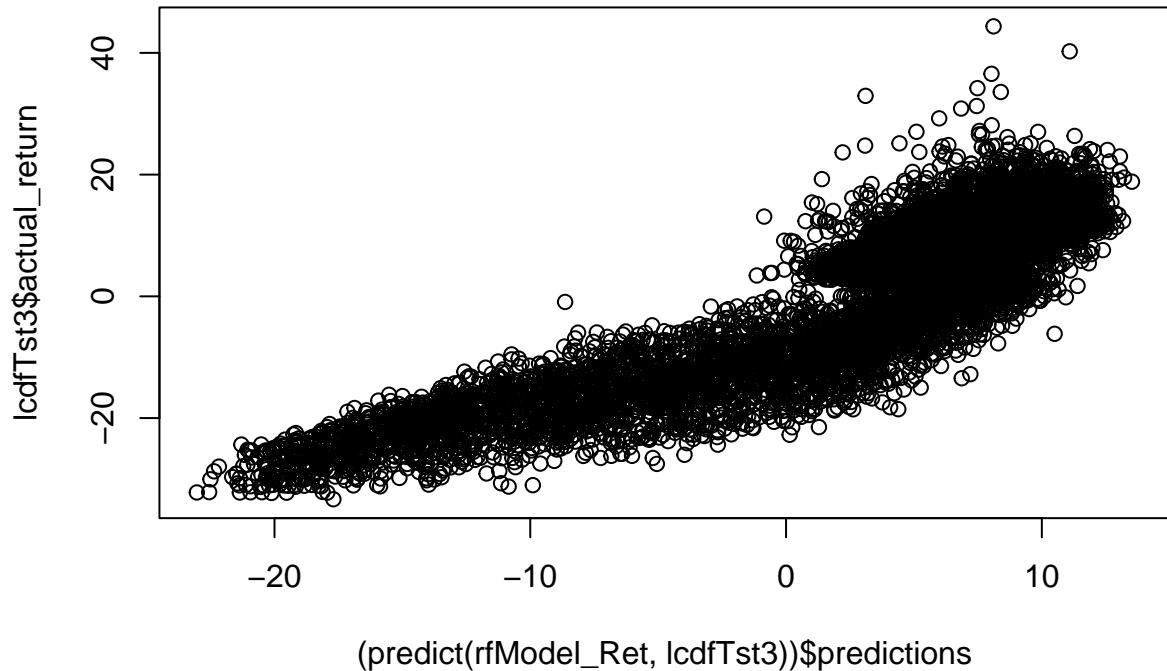
## [1] 2.001759

```

```
#sqrt(mean( (predict(rfModel_Ret, lcdfTst))$predictions - lcdfTst$actualReturn)^2))
plot ( (predict(rfModel_Ret, lcdfTrn3))$predictions, lcdfTrn3$actual_return)
```



```
plot ( (predict(rfModel_Ret, lcdfTst3))$predictions, lcdfTst3$actual_return)
```



```

#Performance by deciles
predRet_Trn <- lpdfTrn3 %>% select(grade, loan_status, actual_return, actual_term, int_rate) %>% mutate(
  predRet_Trn <- predRet_Trn %>% mutate(tile=ntile(-predRet, 10))
  predRet_Trn %>% group_by(tile) %>% summarise(count=n(), avgpredRet=mean(predRet), numDefaults=sum(loan_
  ## # A tibble: 10 x 14
  ##      tile count avgpred~1 numDe~2 avgAc~3 minRet maxRet avgTer totA totB totC
  ##      <int> <int>     <dbl>   <int>   <dbl>   <dbl>   <dbl> <dbl> <int> <int> <int>
  ## 1     1    7000     12.5      4    14.7    9.79   40.8   1.28     1    119   1945
  ## 2     2    7000      9.89     23    11.0    7.24   17.4   1.77     3   1102   3370
  ## 3     3    7000      8.68     46    9.47    5.54   16.6   1.98     8   2387   3449
  ## 4     4    7000      7.74     52    8.22    4.38   13.5   2.25    28   3207   3505
  ## 5     5    7000      6.92    103    7.25    2.67   12.2   2.37   280   4295   2318
  ## 6     6    7000      6.12    123    6.44    0.632   11.6   2.30   1267   4990    667
  ## 7     7    7000      5.24    158    5.52     0    10.6   2.23   3120   3645    178
  ## 8     8    7000      4.38    198    4.46   -1.38    9.11   2.51   5448   1385     97
  ## 9     9    7000      2.75   1902    1.90   -10.8    8.43   2.76   5106   768    674
  ## 10   10    7000     -12.1   6999   -16.4   -33.3     0    3.00   586   1881   2392
  ## # ... with 3 more variables: totD <int>, totE <int>, totF <int>, and
  ## #   abbreviated variable names 1: avgpredRet, 2: numDefaults, 3: avgActRet

library(glmnet)

## Loading required package: Matrix

```

```

## 
## Attaching package: 'Matrix'

## The following objects are masked from 'package:tidyverse':
## 
##     expand, pack, unpack

## Loaded glmnet 4.1-4

xD <- lcdfTrn3 %>% select(-loan_status, -actual_term, -actual_return)
glmRet_cv <- cv.glmnet( data.matrix(xD), lcdfTrn3$actual_return, family="gaussian")
predRet_Trn <- lcdfTrn3 %>% select(grade, loan_status, actual_return, actual_term, int_rate)%>% mutate(
predict(glmRet_cv, data.matrix(lcdfTrn3 %>% select(-loan_status, -actual_term, -actual_return)), s="lambda")
predRet_Trn <- predRet_Trn %>% mutate(tile=ntile(-predRet, 10))

predRet_Trn %>% group_by(tile) %>% summarise(count=n(), avgpredRet=mean(predRet), numDefaults=sum(loan_)

## # A tibble: 10 x 14
##   tile count avgpred~1 numDe~2 avgAc~3  minRet maxRet avgTer totA  totB  totC
##   <int> <int>    <dbl>    <int>    <dbl>    <dbl>    <dbl>    <dbl> <int> <int> <int>
## 1     1    7000    12.8      70    10.2      0    24.5    2.61      2    778  2563
## 2     2    7000     9.14     82     9.57   -0.265    37.7    2.45     27   1849  2799
## 3     3    7000     7.91    118     9.05   -26.9    28.9    2.32    162   2577  2766
## 4     4    7000     7.05    129     8.48   -18.8    40.8    2.21    448   3212  2557
## 5     5    7000     6.36    168     7.87   -25.1    34.2    2.14    931   3526  2030
## 6     6    7000     5.73    185     7.16   -21.0    36.9    2.07   1930   3385  1399
## 7     7    7000     5.11    222     6.39   -30.1    29.5    2.02   3106   2818   867
## 8     8    7000     4.44    358     5.55   -28.5    38.1    1.95   4246   2037   520
## 9     9    7000     3.21   1430     3.48   -31.0    34.8    1.75   4197   1563   774
## 10   10    7000    -9.16   6846   -15.2   -33.3    29.6    2.94    798   2034   2320
## # ... with 3 more variables: totD <int>, totE <int>, totF <int>, and
## #   abbreviated variable names 1: avgpredRet, 2: numDefaults, 3: avgActRet

# 9th Question
# Loan_status model
xpredTst<-predict(xgb_lsM1, dxTst)
scoreTst_xgb_ls <- lcdfTst3 %>% select(grade, loan_status, actual_return, actual_term, int_rate) %>% mutate(
scoreTst_xgb_ls <- scoreTst_xgb_ls %>% mutate(tile=ntile(-score, 10))
scoreTst_xgb_ls %>% group_by(tile) %>% summarise(count=n(), avgSc=mean(score), numDefaults=sum(loan_)

## # A tibble: 10 x 14
##   tile count avgSc numDefaults avgAct~1 minRet maxRet avgTer totA  totB  totC
##   <int> <int> <dbl>    <int>    <dbl>    <dbl>    <dbl>    <dbl> <int> <int> <int>
## 1     1    3000  0.505      430     5.21   -31.1    26.6    2.28    627  1051  812
## 2     2    3000  0.505      419     5.30   -32.2    40.2    2.26    666  1017  792
## 3     3    3000  0.505      438     5.04   -31.3    33.6    2.25    698  965   800
## 4     4    3000  0.505      391     5.34   -31.3    27.0    2.26    701  1015  789
## 5     5    3000  0.505      414     5.19   -32.2    27.2    2.25    684  1009  819
## 6     6    3000  0.505      410     5.37   -32.2    25.1    2.24    696  992   827
## 7     7    3000  0.505      421     5.41   -32.2    34.2    2.22    661  995   847
## 8     8    3000  0.505      438     5.15   -33.3    44.4    2.26    651  1047  770
## 9     9    3000  0.501      398     5.50   -31.0    36.6    2.26    686  1027  791

```

```
## 10    10 3000 0.495      418     5.34 -32.3   24.9   2.27   671  1010   803
## # ... with 3 more variables: totD <int>, totE <int>, totF <int>, and
## #   abbreviated variable name 1: avgActRet
```