AllTheCode

load packages

```
# feature exploration engineering
library(tidyverse) # ggplot, dplyr
library(lubridate) # month()
library(gridExtra) # grid.arrange()
library(caret) # dummyVars()
# subset selection
library(glmnet) # lasso
library(randomForest) # for checking importance()
library(coefplot) # extract.coef()
# model
library(xgboost)
```

load data

```
train <- read_csv('training.csv')
test <- read_csv('test.csv')
test_id = test$id
```

preprocessing

creating high levels for Channel Features

```
attach(train)
train$Num_Subscribers_Base_high <- as.integer(Num_Subscribers_Base_low == 0 & Num_Subscribers_Base_low_
train$Num_Views_Base_high <- as.integer(Num_Views_Base_low == 0 & Num_Views_Base_low_mid == 0 & Num_Vie
train$avg_growth_high <- as.integer(avg_growth_low == 0 & avg_growth_low_mid == 0 & avg_growth_mid_high
train$count_vids_high <- as.integer(count_vids_low == 0 & count_vids_low_mid == 0 & count_vids_mid_high
detach(train)
attach(test)
test$Num_Subscribers_Base_high <- as.integer(Num_Subscribers_Base_low == 0 & Num_Subscribers_Base_low_m
test$Num_Views_Base_high <- as.integer(Num_Views_Base_low == 0 & Num_Views_Base_low_mid == 0 & Num_View
test$count_vids_high <- as.integer(count_vids_low == 0 & count_vids_low_mid == 0 & count_vids_mid_high 
test$avg_growth_high <- as.integer(avg_growth_low == 0 & avg_growth_low_mid == 0 & avg_growth_mid_high 
detach(test)
```

converting datetime to numeric (and time-based features)

```
# split PublishedDate into date and time
train <- train %>% separate(PublishedDate,c("PublishedDate","PublishedTime"),sep = " ")
test <- test %>% separate(PublishedDate,c("PublishedDate","PublishedTime"),sep = " ")
train$PublishedDate <- strptime(train$PublishedDate, "%m/%d/%Y")
```

```r
train$PublishedTime <- strptime(train$PublishedTime, "%H:%M")
test$PublishedDate <- strptime(test$PublishedDate, "%m/%d/%Y")
test$PublishedTime <- strptime(test$PublishedTime, "%H:%M")

# convert time to mins since midnight (numeric)
MinsSince1 <- as.integer(train$PublishedTime - min(train$PublishedTime))/60 # store as minutes
train <- cbind(MinsSince1,train)
MinsSince1 <- as.integer(test$PublishedTime - min(test$PublishedTime))/60 # store as minutes
test <- cbind(MinsSince1,test)
# and date to days since first day (numeric)
DaysSince1 <- as.integer(train$PublishedDate - min(train$PublishedDate))/86400 # store as days
train <- cbind(DaysSince1,train)
DaysSince1 <- as.integer(test$PublishedDate - min(test$PublishedDate))/86400 # store as days
test <- cbind(DaysSince1,test)

# creat hour bins (4 hours per bin)
train$bin_hour <- as.factor(train$MinsSince1 %/% 240)
test$bin_hour <- as.factor(test$MinsSince1 %/% 240)
# one-hot encode hour bins
dmy <- dummyVars(" ~ bin_hour", data = train)
trsf <- data.frame(predict(dmy, newdata = train))
train <- cbind(train,trsf)
dmy <- dummyVars(" ~ bin_hour", data = test)
trsf <- data.frame(predict(dmy, newdata = test))
test <- cbind(test,trsf)

# create month
train$month <-  as.factor(month(as.Date(train$PublishedDate)))
test$month <-  as.factor(month(as.Date(test$PublishedDate)))
# one-hot encode month
dmy <- dummyVars(" ~ month", data = train)
trsf <- data.frame(predict(dmy, newdata = train))
train <- cbind(train,trsf)
dmy <- dummyVars(" ~ month", data = test)
trsf <- data.frame(predict(dmy, newdata = test))
test <- cbind(test,trsf)
train$month <-  as.integer(train$month)
test$month <-  as.integer(test$month)

# day of week
train$day_of_week <- weekdays(as.Date(train$PublishedDate))
test$day_of_week <- weekdays(as.Date(test$PublishedDate))
# one hot encode DoW
dmy <- dummyVars(" ~ day_of_week", data = train)
trsf <- data.frame(predict(dmy, newdata = train))
train <- cbind(train,trsf)
dmy <- dummyVars(" ~ day_of_week", data = test)
trsf <- data.frame(predict(dmy, newdata = test))
test <- cbind(test,trsf)
```

creating title features

```
# avg word length
train$avg_word_length <- train$num_chars/train$num_words
test$avg_word_length <- test$num_chars/test$num_words
# number of non-stopwords
train$num_non_stopwords <- train$num_words - train$num_stopwords
test$num_non_stopwords <- test$num_words - test$num_stopwords
# proportion of non-stopwords
train$p_non_stopwords <- train$num_non_stopwords/train$num_words
test$p_non_stopwords <- test$num_non_stopwords/test$num_words
# proportion of digit chars
train$p_digit_chars <- train$num_digit_chars/train$num_chars
test$p_digit_chars <- test$num_digit_chars/test$num_chars
# whether a title has a word with multiple capital letters
train$all_cap <- as.integer(train$num_uppercase_chars > train$num_uppercase_words) # (more uppercase ch
test$all_cap <- as.integer(test$num_uppercase_chars > test$num_uppercase_words)
```

converting some punctuation to binary

the only punctuation predictors in our final model were: punc_num_at punc_num_bar_bi and punc_num_com

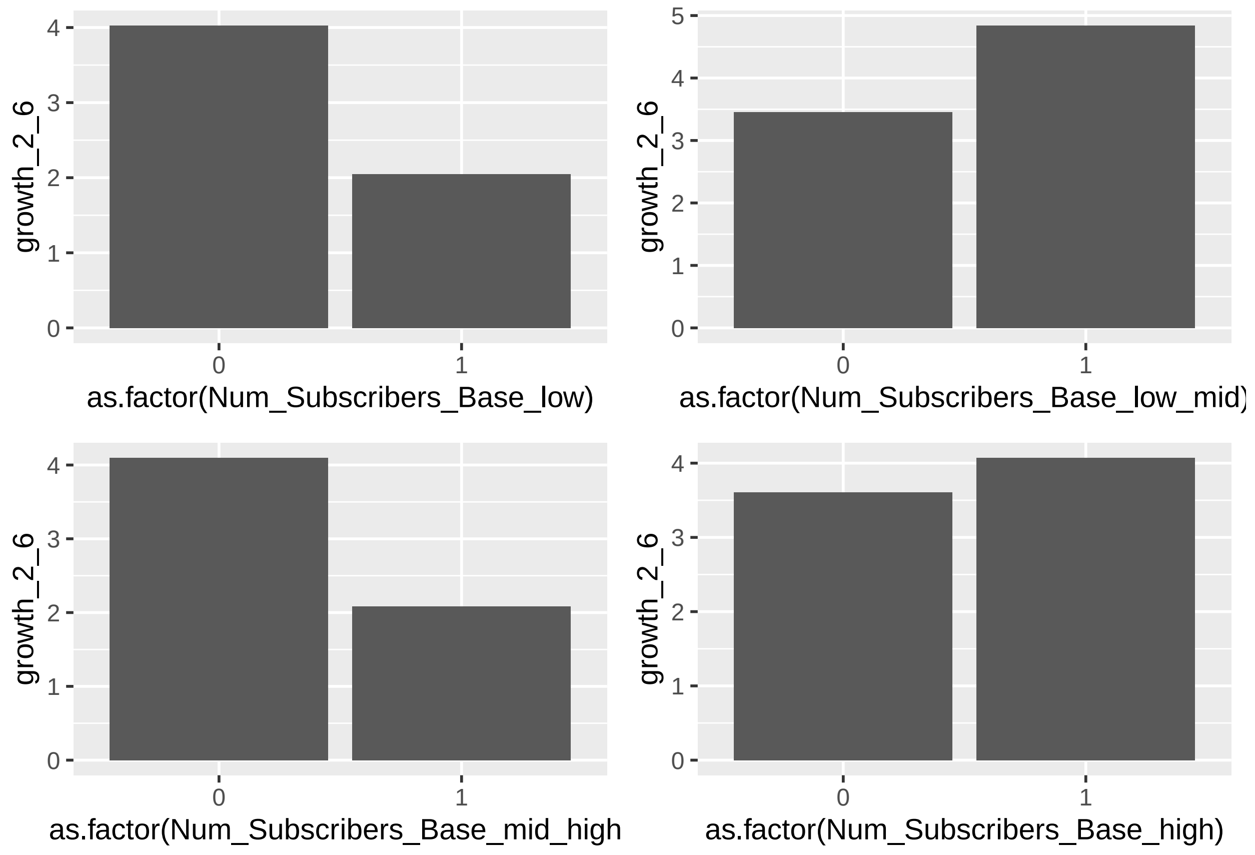
```
# had some difficulties with special characters, so renamed them
train <- train %>% rename(`punc_num_fs` = "punc_num_/",
                          `punc_num_bs` = "punc_num_\\",
                          `punc_num_col` = "punc_num_:",
                          `punc_num_bar` = "punc_num_|",
                          `punc_num_exc` = "punc_num_!",
                          `punc_num_num` = "punc_num_#",
                          `punc_num_pls` = "punc_num_+",
                          `punc_num_par_l` = "punc_num_(",
                          `punc_num_par_r` = "punc_num_)",
                          `punc_num_at` = "punc_num_@",
                          `punc_num_eql` = "punc_num_=",
                          `punc_num_q` = "punc_num_?",
                          `punc_num_dol` = "punc_num_$",
                          `punc_num_pct` = "punc_num_%",
                          `punc_num_com` = "punc_num_,",
                          `punc_num_semi` = "punc_num_;",
                          `punc_num_dash` = "punc_num_-",
                          `punc_num_dot` = "punc_num_.",
                          `punc_num_brk_l` = "punc_num_[",
                          `punc_num_crl_l` = "punc_num_{",
                          `punc_num_brk_r` = "punc_num_]",
                          `punc_num_crl_r` = "punc_num_}",
                          `punc_num_leq` = "punc_num_<",
                          `punc_num_geq` = "punc_num_>",
                          `punc_num_crt` = "punc_num_^",
                          `punc_num_and` = "punc_num_&",
                          `punc_num_dquo` = 'punc_num_"',
                          `punc_num_squo` = "punc_num_'",
                          `punc_num_bktk` = "punc_num_`",
                          `punc_num_ast` = "punc_num_*",
                          `punc_num_tld` = "punc_num_~"
                          )
# names(train)[235]
test <- test %>% rename(`punc_num_fs` = "punc_num_/",
                        `punc_num_bs` = "punc_num_\\",
                        `punc_num_col` = "punc_num_:",
                        `punc_num_bar` = "punc_num_|",
                        `punc_num_exc` = "punc_num_!",
                        `punc_num_num` = "punc_num_#",
                        `punc_num_pls` = "punc_num_+",
                        `punc_num_par_l` = "punc_num_(",
                        `punc_num_par_r` = "punc_num_)",
                        `punc_num_at` = "punc_num_@",
                        `punc_num_eql` = "punc_num_=",
                        `punc_num_q` = "punc_num_?",
                        `punc_num_dol` = "punc_num_$",
                        `punc_num_pct` = "punc_num_%",
                        `punc_num_com` = "punc_num_,",
                        `punc_num_semi` = "punc_num_;",
                        `punc_num_dash` = "punc_num_-",
                        `punc_num_dot` = "punc_num_.",
                        `punc_num_brk_l` = "punc_num_[",
                        `punc_num_crl_l` = "punc_num_{",
                        `punc_num_brk_r` = "punc_num_]",
                        `punc_num_crl_r` = "punc_num_}",
                        `punc_num_leq` = "punc_num_<",
                        `punc_num_geq` = "punc_num_>",
                        `punc_num_crt` = "punc_num_^",
                        `punc_num_and` = "punc_num_&",
                        `punc_num_dquo` = 'punc_num_"',
                        `punc_num_squo` = "punc_num_'",
                        `punc_num_bktk` = "punc_num_`",
                        `punc_num_ast` = "punc_num_*",
                        `punc_num_tld` = "punc_num_~"
                        )
# we found these values by checking whether there was a significant difference
# in growth_2_6 for the most common punctuations (so cutoff somewhat subjective)
train$punc_num_bar_bi <- as.integer(train$punc_num_bar == 1) # eq 1 is opt
test$punc_num_bar_bi <- as.integer(test$punc_num_bar == 1) # eq 1 is opt
```

other features

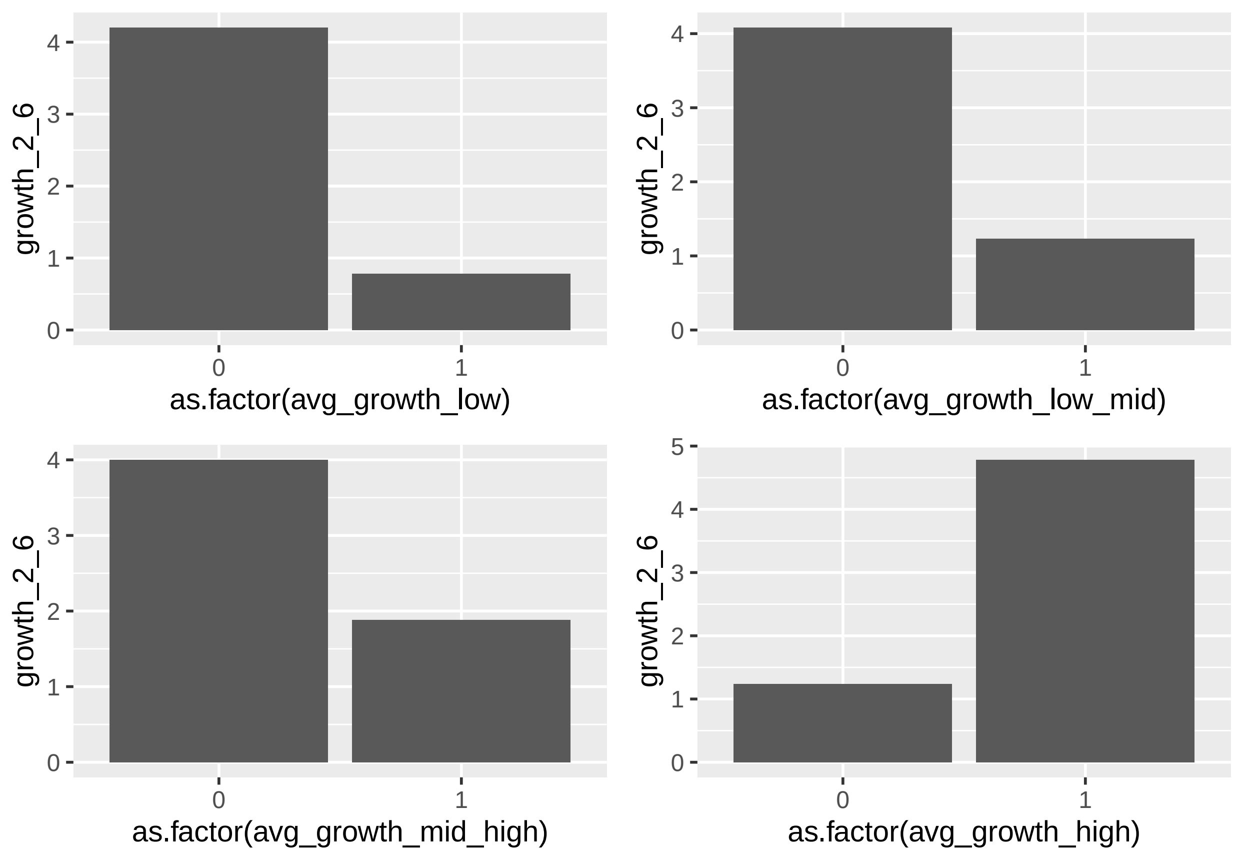
```
# convert duration to binary
train$Duration2 <- as.integer(train$Duration > 6000)
test$Duration2 <- as.integer(test$Duration > 6000)
```

exploring features

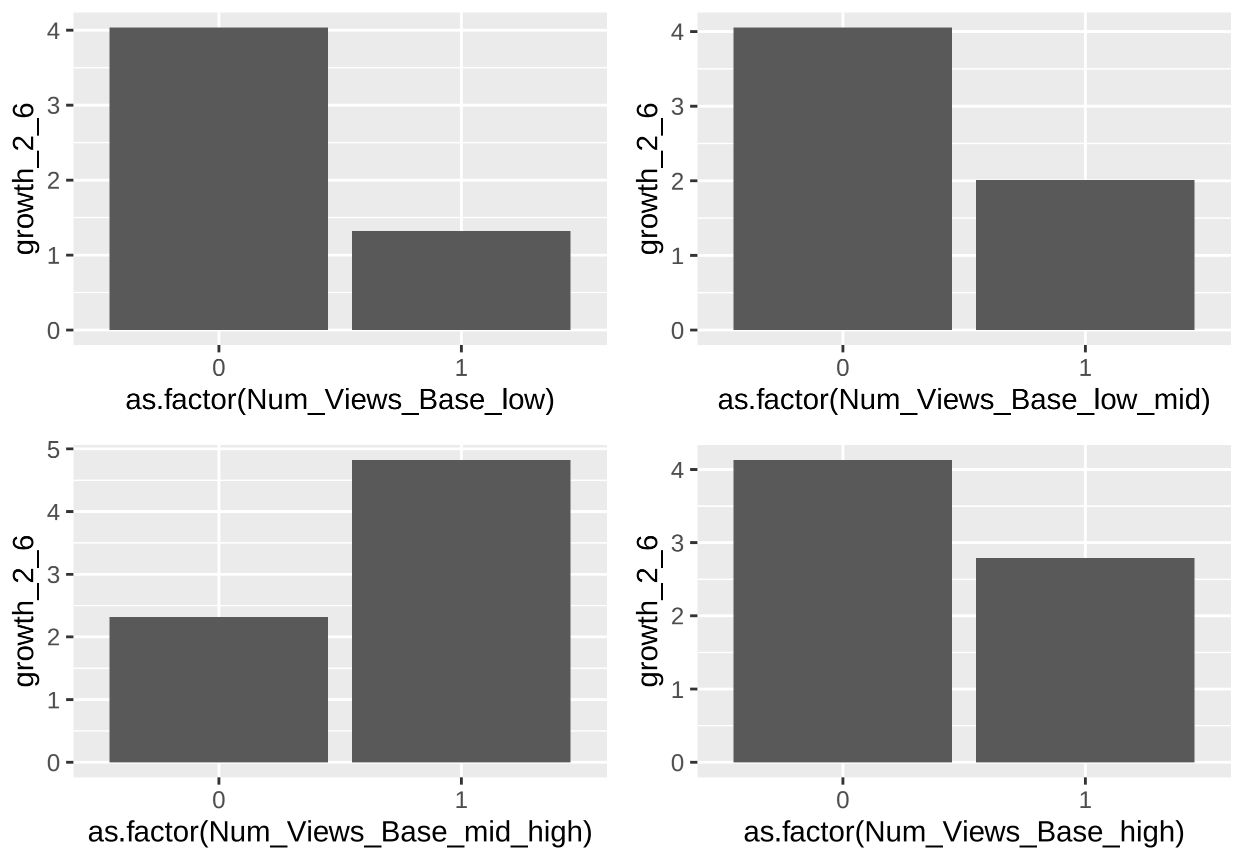
```
# subscribers
p1 <- ggplot(train,aes(x=as.factor(Num_Subscribers_Base_low),y=growth_2_6)) + stat_summary(fun = "mean"
p2 <- ggplot(train,aes(x=as.factor(Num_Subscribers_Base_low_mid),y=growth_2_6)) + stat_summary(fun = "me
p3 <- ggplot(train,aes(x=as.factor(Num_Subscribers_Base_mid_high),y=growth_2_6)) + stat_summary(fun = "
p4 <- ggplot(train,aes(x=as.factor(Num_Subscribers_Base_high),y=growth_2_6)) + stat_summary(fun = "mean
grid.arrange(p1,p2,p3,p4,nrow=2)
```



```
# average growth
p1 <- ggplot(train,aes(x=as.factor(avg_growth_low),y=growth_2_6)) + stat_summary(fun = "mean", geom = "
p2 <- ggplot(train,aes(x=as.factor(avg_growth_low_mid),y=growth_2_6)) + stat_summary(fun = "mean", geom
p3 <- ggplot(train,aes(x=as.factor(avg_growth_mid_high),y=growth_2_6)) + stat_summary(fun = "mean", geo
p4 <- ggplot(train,aes(x=as.factor(avg_growth_high),y=growth_2_6)) + stat_summary(fun = "mean", geom =
grid.arrange(p1,p2,p3,p4,nrow=2) # growth highest for high avg_growth
```

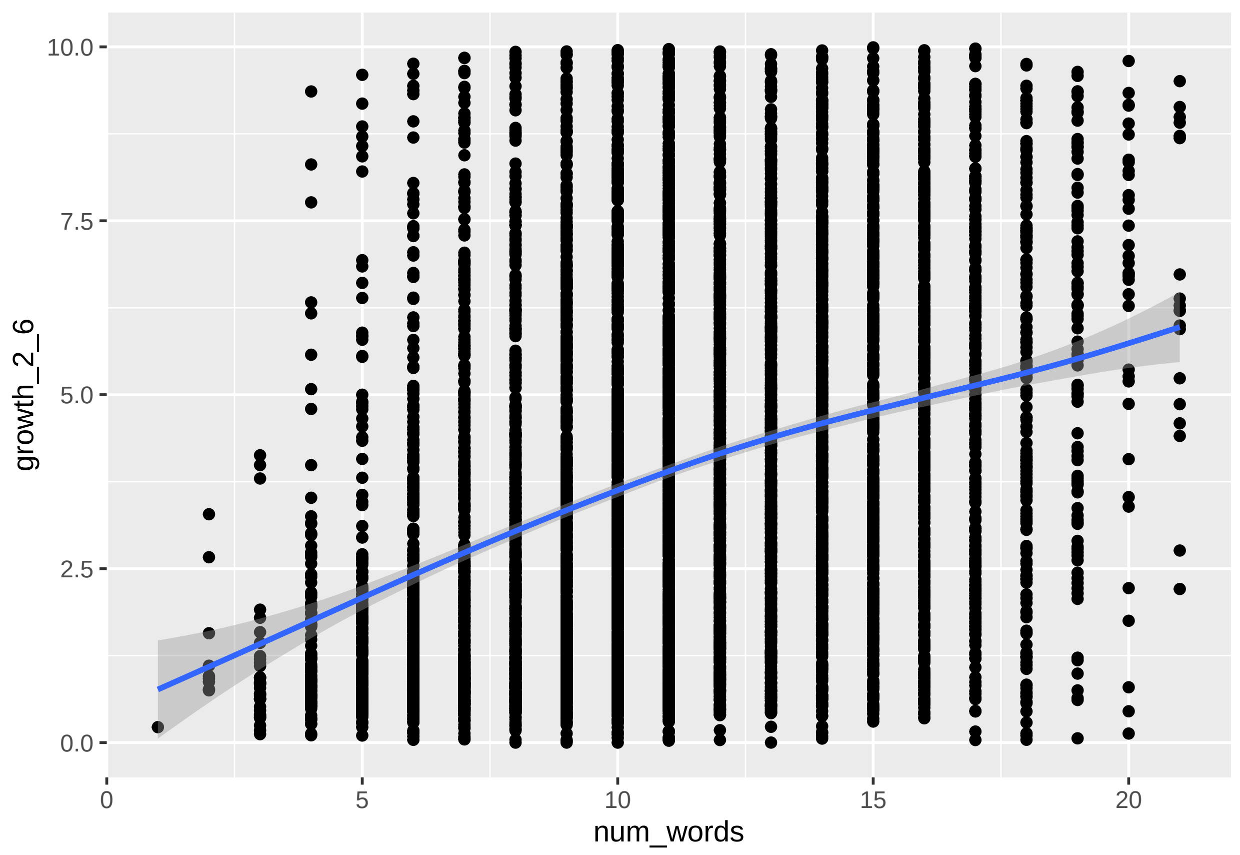


```
# number of views on channel
p1 <- ggplot(train,aes(x=as.factor(Num_Views_Base_low),y=growth_2_6)) + stat_summary(fun = "mean", geom
p2 <- ggplot(train,aes(x=as.factor(Num_Views_Base_low_mid),y=growth_2_6)) + stat_summary(fun = "mean", 
p3 <- ggplot(train,aes(x=as.factor(Num_Views_Base_mid_high),y=growth_2_6)) + stat_summary(fun = "mean",
p4 <- ggplot(train,aes(x=as.factor(Num_Views_Base_high),y=growth_2_6)) + stat_summary(fun = "mean", geom
grid.arrange(p1,p2,p3,p4,nrow=2) # growth highest for Num_Views_Base_mid_high (too high is not good)
```



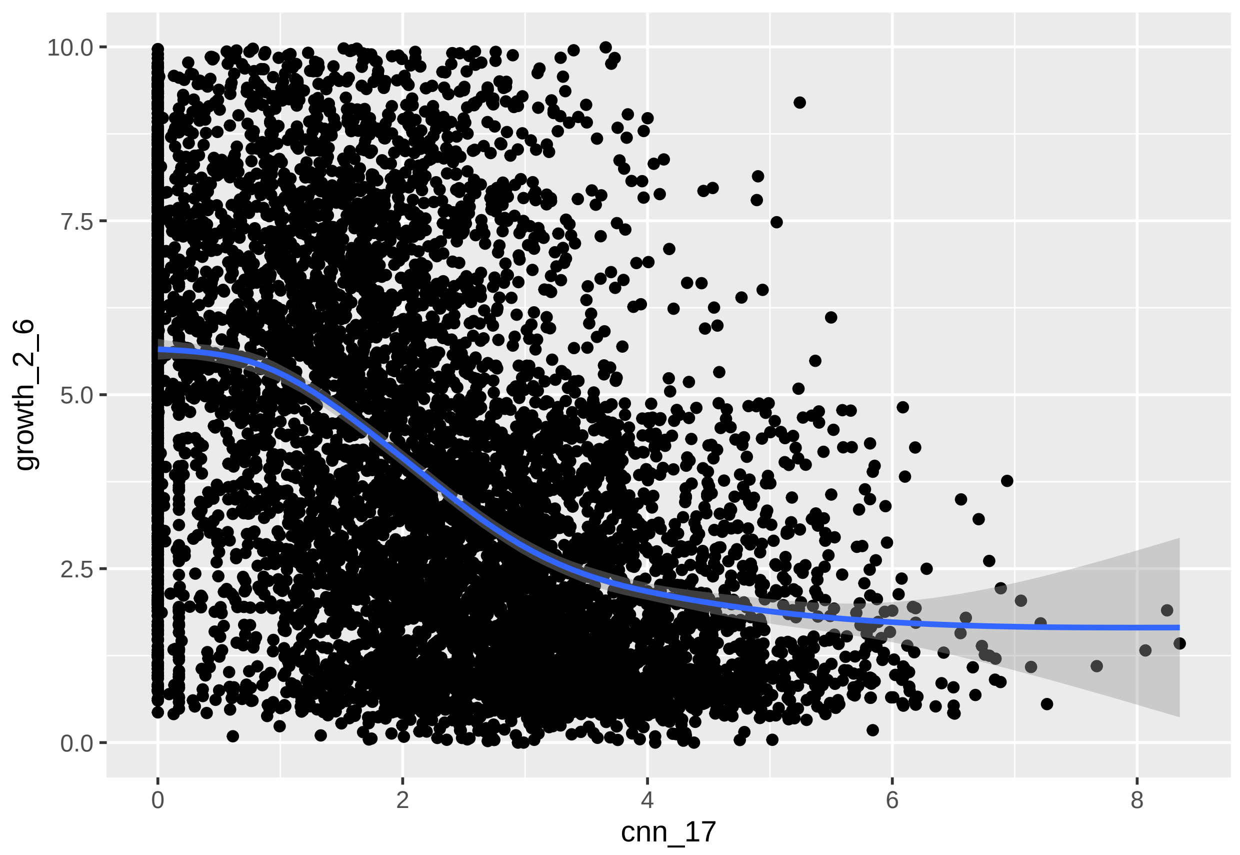
```
# some other significant features
ggplot(train,aes(x=num_words,y=growth_2_6)) + geom_point() + geom_smooth() # num words
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```



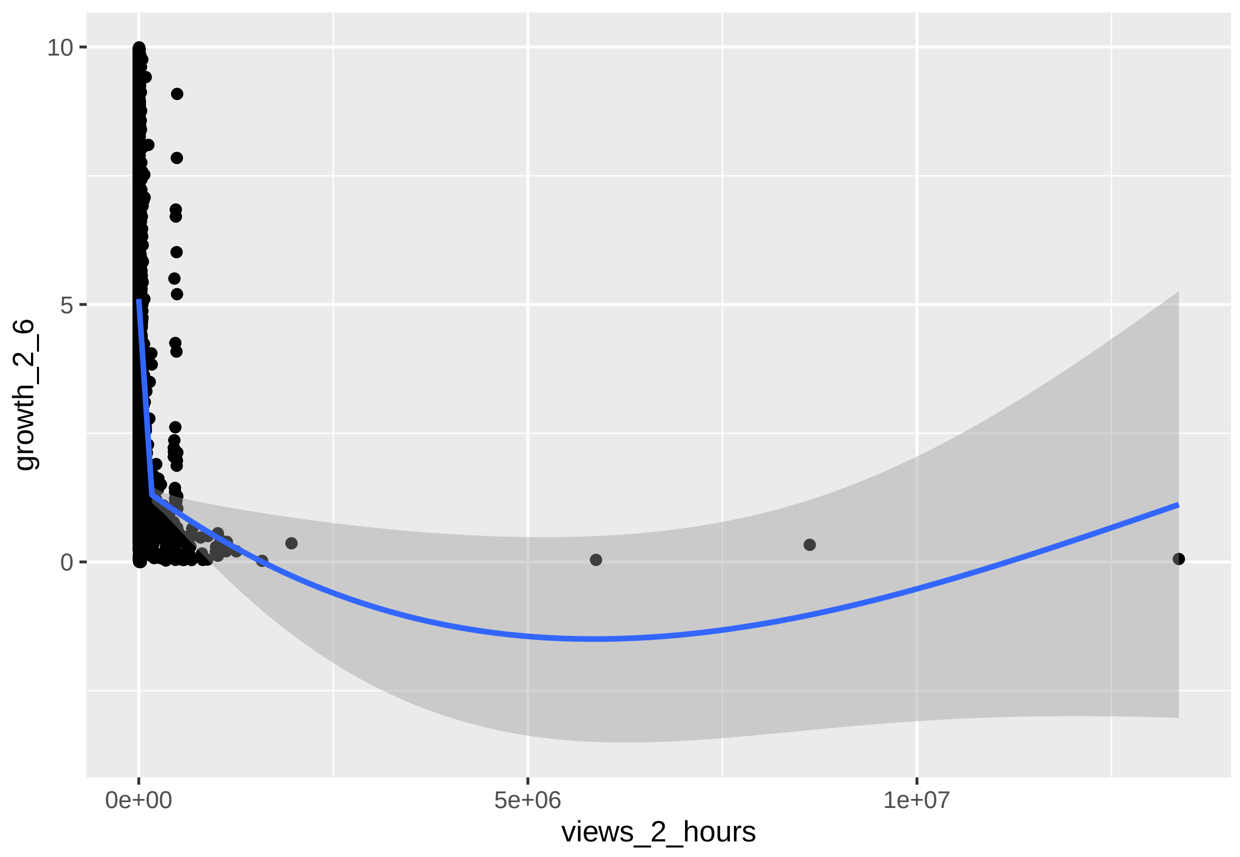
```
ggplot(train,aes(x=cnn_17,y=growth_2_6)) + geom_point() + geom_smooth() # cnn_17
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```



```
ggplot(train,aes(x=views_2_hours,y=growth_2_6)) + geom_point() + geom_smooth() # views_2_hours
```

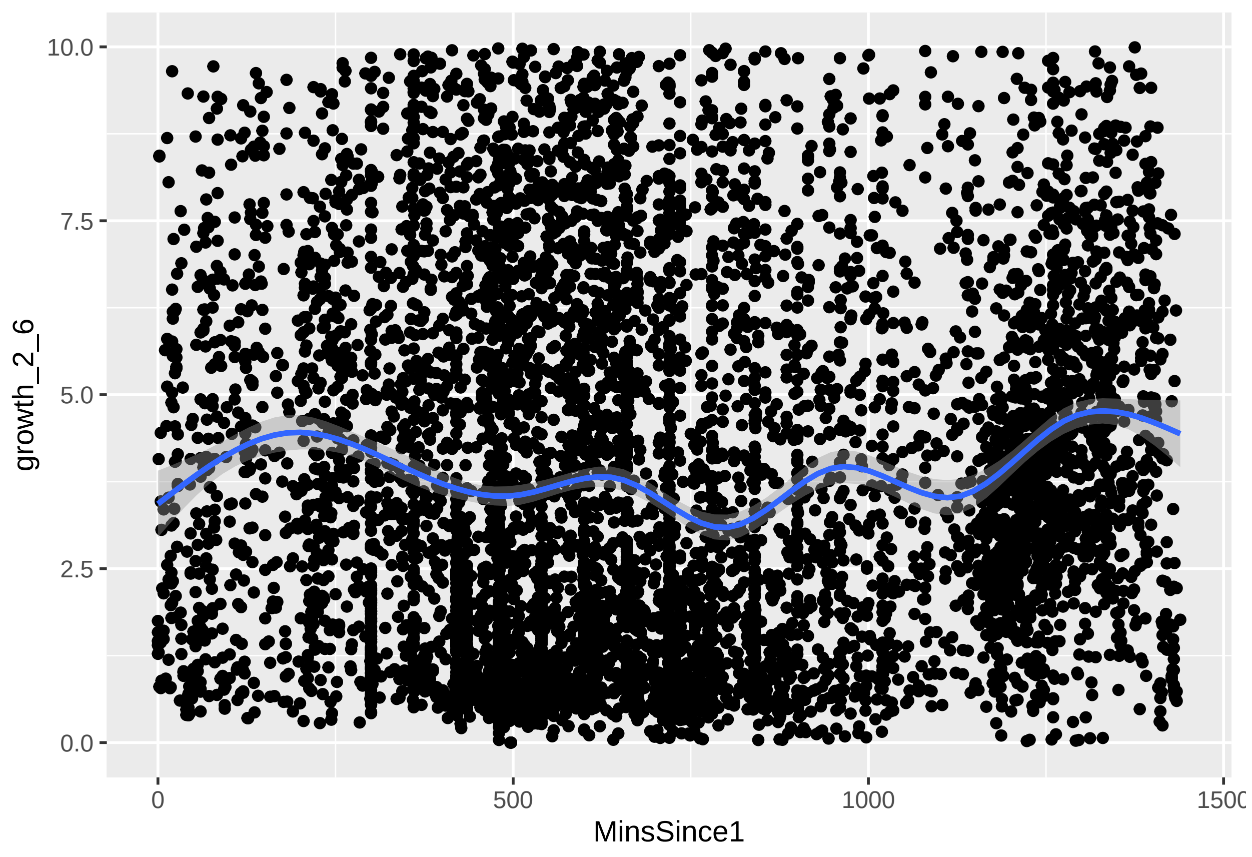
```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```



## exploring our created features

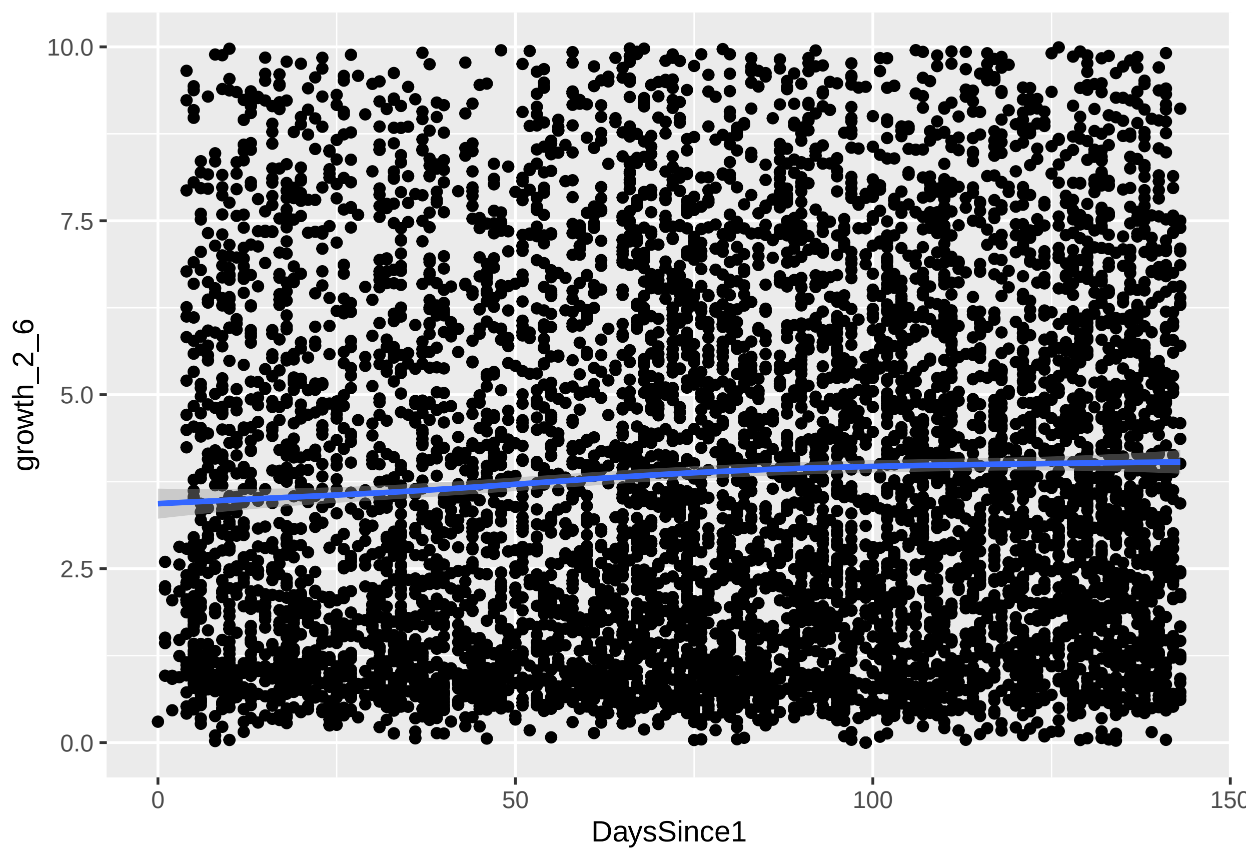
```
# numeric date and time, and binary duration
ggplot(train,aes(x=MinsSince1,y=growth_2_6)) + geom_point() + geom_smooth()
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```

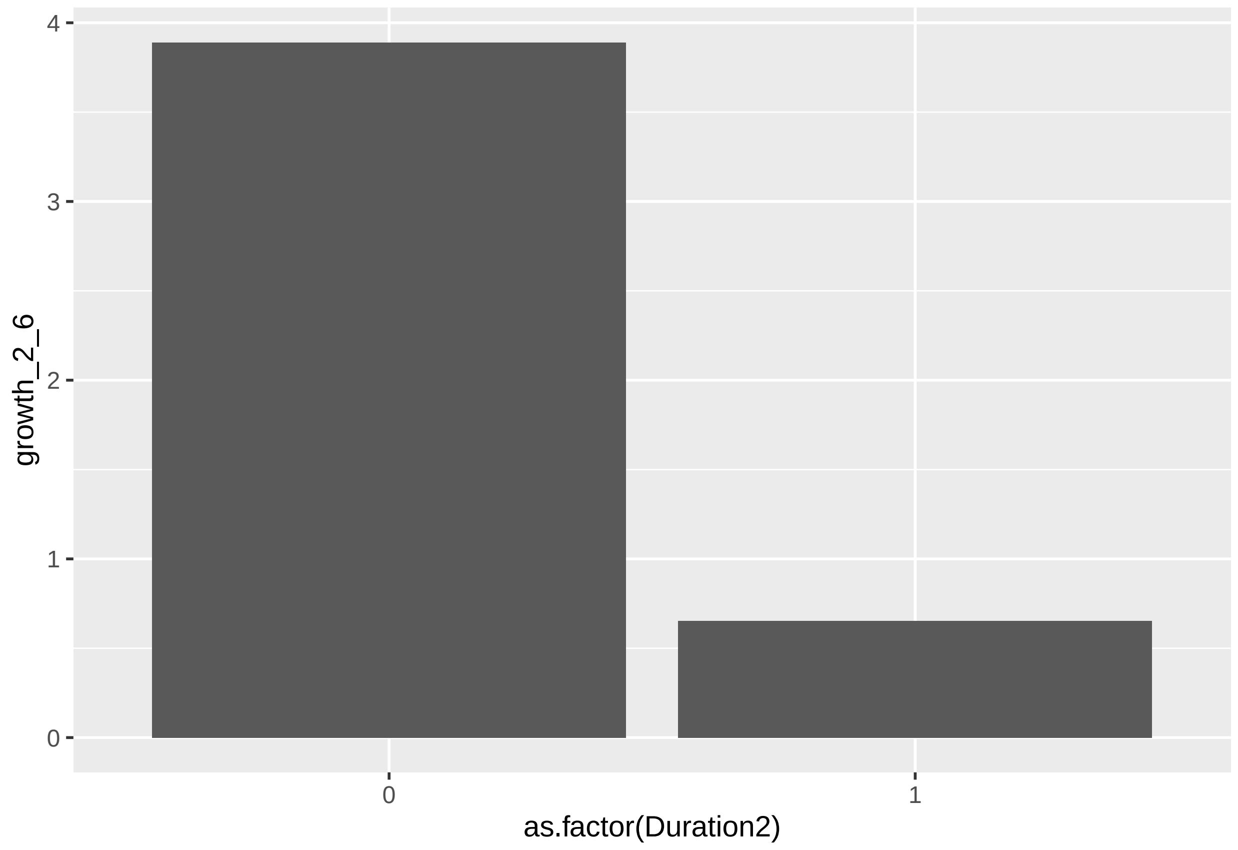


```r
ggplot(train,aes(x=DaysSince1,y=growth_2_6)) + geom_point() + geom_smooth()
```

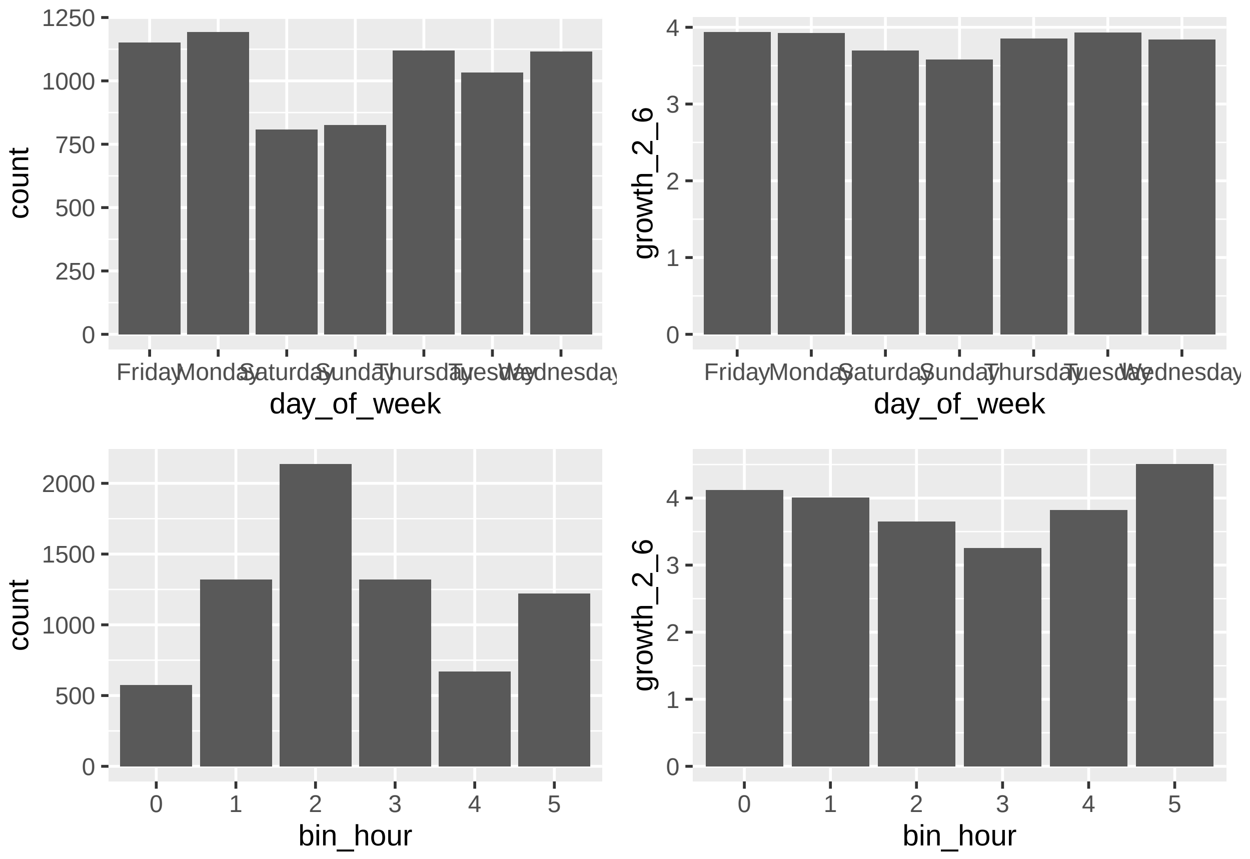
```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```



```
ggplot(train,aes(x=as.factor(Duration2),y=growth_2_6)) + stat_summary(fun = "mean", geom = "col") #
```



```
# day of week
p1 <- ggplot(train) + geom_bar(aes(x=day_of_week)) # lower uploads on saturday and sunday, Mondays, Fri
p2 <- ggplot(train,aes(x=day_of_week,y=growth_2_6)) + stat_summary(fun = "mean", geom = "col")# geom_ba
# hour of day
p3 <- ggplot(train) + geom_bar(aes(x=bin_hour)) # upload time dist
p4 <- ggplot(train,aes(x=bin_hour,y=growth_2_6)) + stat_summary(fun = "mean", geom = "col")#+ geom_bar(
grid.arrange(p1,p2,p3,p4,nrow=2)
```



variable selection

first remove all non-numeric features

```
train <- train %>% select(-c(PublishedDate,PublishedTime,day_of_week,bin_hour))
# and move growth to last col
train <- train %>% relocate(growth_2_6, .after = last_col())
```

RFE subselect

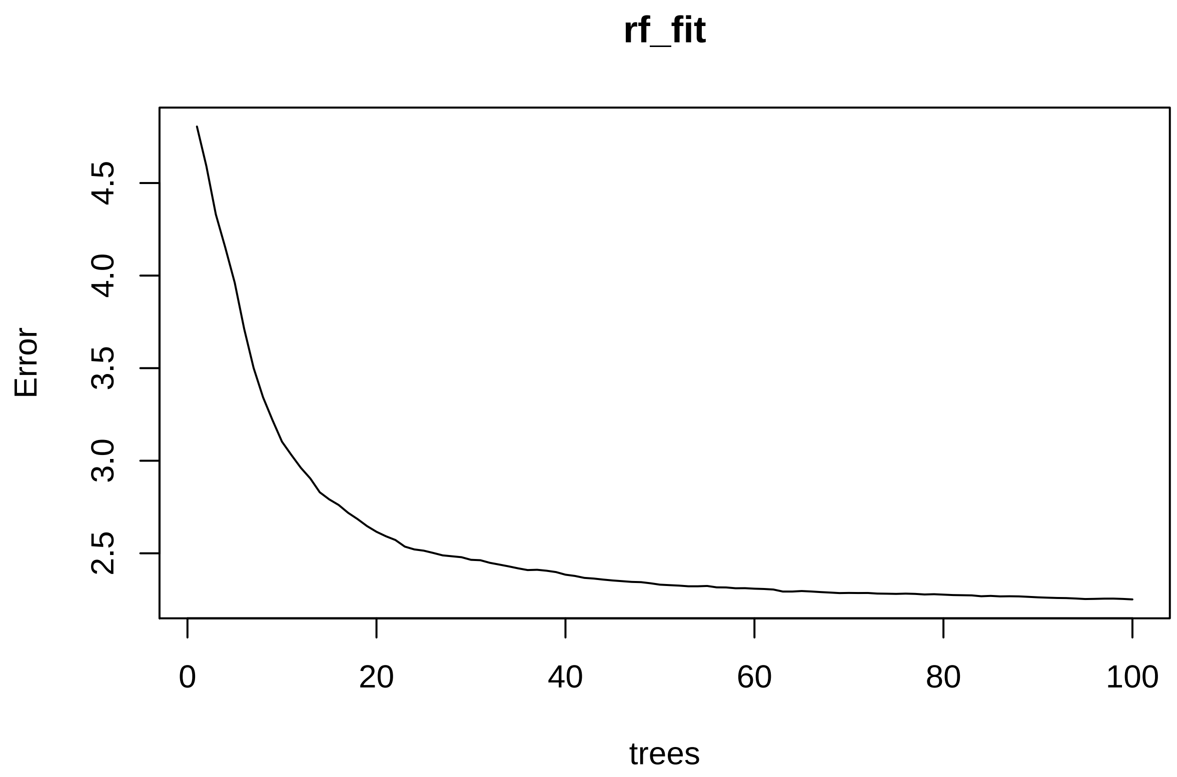
```
# the code takes hours to run
# so we have commented it out

# set.seed(22)
# subsets <- c(30:40)
# control <- rfeControl(functions=rfFuncs,
#                       method="cv",
#                       number=10,
#                       verbose=T)
# x <- train[,-which(colnames(train)=="growth_2_6")]
# y <- as.matrix(train[,which(colnames(train)=="growth_2_6")])
# rfe_sub <- rfe(x,y,
#                sizes=subsets,
#                rfeControl = control)
# # final variables
# paste(rfe_sub$optVariables,collapse = " ")
```

RF importance

```
# variables sorted by importance for Random Forest
rf_fit = randomForest(growth_2_6~., data = train,
                         ntree = 100,
                         mtry= floor(ncol(train)/3),
                         trControl = oob_control,
                         importance=TRUE)
incMSE_Imp <- importance(rf_fit)[,"%IncMSE"] %>% sort(decreasing = T)
paste(names(incMSE_Imp[incMSE_Imp >= 1]),collapse=" ")
```

```
## [1] "avg_growth_high cnn_10 cnn_86 cnn_89 Num_Subscribers_Base_low_mid cnn_17 views_2_hours cnn_25 Nu
```

```
plot(rf_fit)
```



## lasso subselect

```
X_train = model.matrix(growth_2_6~., train)
y_train = train$growth_2_6

lasso_fit <- cv.glmnet(X_train,y_train,data = train, family = "gaussian", alpha = 1, #lambda = 0.00208,
                     standardize = TRUE)
lasso_coeffs <- extract.coef(lasso_fit) %>% arrange(desc(abs(Value)))
paste(lasso_coeffs$Coefficient[1:93],collapse = " ")
```

```
## [1] "(Intercept) avg_growth_high Num_Subscribers_Base_low_mid hog_116 punc_num_bktk hog_454 hog_641 
```

final set of predictors chosen from above 3 methods

```
subset <- unlist(strsplit("avg_growth_high avg_growth_low avg_growth_low_mid avg_growth_mid_high bin_hou
train <- train[c(subset,"growth_2_6")]
```

creating model

Split train and test

```
set.seed(22)
train_index <- createDataPartition(train$growth_2_6, p = 0.7,
          list = FALSE)
train <- train[train_index,]
valid <- train[-train_index,]
dim(train)
```

```
## [1] 5070   41
```

```
dim(valid)
```

```
## [1] 1514   41
```

Format data for XGBoost

```
# xgboost requires data as matrix, and response separated from predictors
trainm <- train %>% dplyr::select(-c(growth_2_6)) %>% as.matrix()
train_label <- as.matrix(train[,"growth_2_6"])
train_matrix <- xgb.DMatrix(data = as.matrix(trainm),label = train_label)

# do same for valid
validm <- valid %>% dplyr::select(-growth_2_6) %>% as.matrix()
valid_label <- as.matrix(valid[,"growth_2_6"])
valid_matrix <- xgb.DMatrix(data = as.matrix(validm),label = valid_label)
```

Parameter tuning through cv

```
watchlist <- list(train = train_matrix, test = valid_matrix)
set.seed(22)
best_param = list()
best_RMSE = Inf
best_RMSE_index = 0

for (iter in 1:100){
  xgb_params <- list("objective" = "reg:squarederror",
                    "eval_metric" = "rmse",
                    "eta" = runif(1,0.01,0.3), # learning rate: sample 1 between 0.01 and 0.3
                    "lambda" = runif(1,1,2), # (default 1) larger lambda -> less overfit
                    "gamma"=runif(1,0,0.2), # (default 0) similar to lambda
                    "subsample"=runif(1,0.6,0.9), # fraction of observations to sample per tree
                    "colsample_bytree"=runif(1,0.5,0.8), # simliar to mtry in RF (but proportion)
                    "min_child_weight"=sample(1:40, 1) # higher values -> less overfit
```

```r
                   )
  seed.number = sample.int(10000, 1)[[1]] # also set random seed
  set.seed(seed.number)
  cv.nround = 100 # need to cv on enough rounds too
  cv.nfold = 5
  xgb_cv <- xgb.cv(params = xgb_params,
                  data = train_matrix,
                  nrounds = cv.nround,
                  nfold = cv.nfold,
                  early_stopping_rounds = 8, # stop if rmse does not decrease in 8 rounds
                  maximize = F, # minimizing RMSE
                  verbose=F)
  min_RMSE = min(xgb_cv$evaluation_log[, test_rmse_mean]) # find minumum RMSE of n rounds
  min_RMSE_index = which.min(xgb_cv$evaluation_log[, test_rmse_mean]) # index of min RMSE

  if (min_RMSE < best_RMSE) {
      best_RMSE = min_RMSE
      best_RMSE_index = min_RMSE_index
      best_seednumber = seed.number
      best_param = xgb_params
  }
  if(iter %% 5 == 0){
    print(paste("Completed iteration ", iter))
    print(paste("Stopped at ", best_RMSE_index))
    print(paste("Current best RMSE ", best_RMSE))
  }
}
```

```
## [1] "Completed iteration  5"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4617234"
## [1] "Completed iteration  10"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4617234"
## [1] "Completed iteration  15"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4525334"
## [1] "Completed iteration  20"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4525334"
## [1] "Completed iteration  25"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4525334"
## [1] "Completed iteration  30"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4525334"
## [1] "Completed iteration  35"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4525334"
## [1] "Completed iteration  40"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4525334"
## [1] "Completed iteration  45"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4525334"
## [1] "Completed iteration  50"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4525334"
## [1] "Completed iteration  55"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4511512"
## [1] "Completed iteration  60"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4511512"
## [1] "Completed iteration  65"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4511512"
## [1] "Completed iteration  70"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4511512"
## [1] "Completed iteration  75"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4511512"
## [1] "Completed iteration  80"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4511512"
## [1] "Completed iteration  85"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4511512"
## [1] "Completed iteration  90"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4511512"
## [1] "Completed iteration  95"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4511512"
## [1] "Completed iteration  100"
## [1] "Stopped at  100"
## [1] "Current best RMSE  1.4511512"
```

```
best_seednumber
```

```
## [1] 557
```

```
best_RMSE_index # number of rounds with best RMSE
```

```
## [1] 100
```

```
best_param # best parameter values for that round
```

```
## $objective
## [1] "reg:squarederror"
##
## $eval_metric
## [1] "rmse"
##
## $eta
## [1] 0.07636546
##
## $lambda
## [1] 1.920363
```

```
##
## $gamma
## [1] 0.04588421
##
## $subsample
## [1] 0.763911
##
## $colsample_bytree
## [1] 0.6528408
##
## $min_child_weight
## [1] 16
```

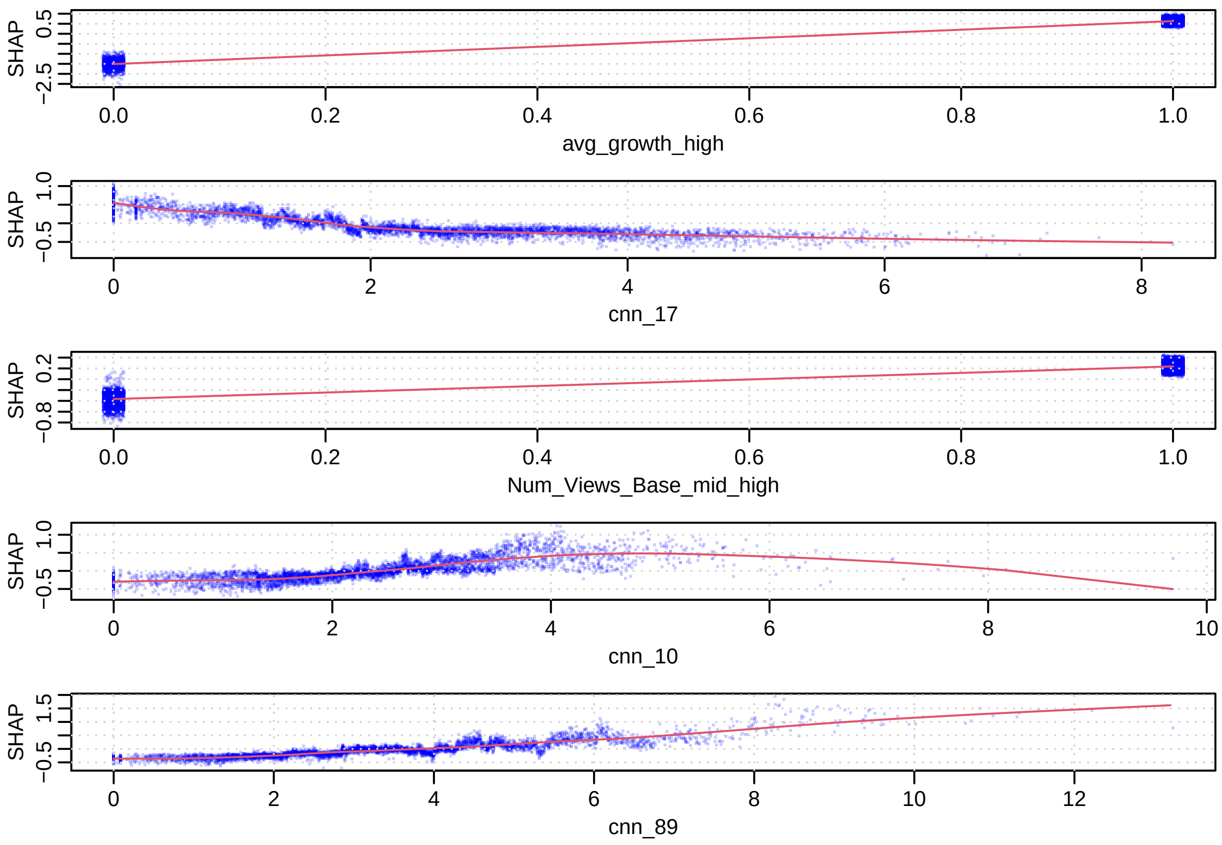
Create model with tuned parameters

```
set.seed(best_seednumber)
xgb_fit <- xgb.train(data=train_matrix,
                params=best_param,
                nrounds=500,
                watchlist = watchlist)
```

```
## [1]  train-rmse:3.980966 test-rmse:3.940549
## [2]  train-rmse:3.730891 test-rmse:3.690175
## [3]  train-rmse:3.502533 test-rmse:3.461638
## [4]  train-rmse:3.293606 test-rmse:3.252409
## [5]  train-rmse:3.103177 test-rmse:3.062833
## [6]  train-rmse:2.928995 test-rmse:2.889175
## [7]  train-rmse:2.769187 test-rmse:2.727262
## [8]  train-rmse:2.627423 test-rmse:2.586733
## [9]  train-rmse:2.499185 test-rmse:2.457024
## [10] train-rmse:2.382979 test-rmse:2.340647
## [11] train-rmse:2.276610 test-rmse:2.234018
## [12] train-rmse:2.177235 test-rmse:2.135351
## [13] train-rmse:2.088336 test-rmse:2.046504
## [14] train-rmse:2.007513 test-rmse:1.964225
## [15] train-rmse:1.937313 test-rmse:1.892909
## [16] train-rmse:1.873425 test-rmse:1.828277
## [17] train-rmse:1.817077 test-rmse:1.770338
## [18] train-rmse:1.763414 test-rmse:1.717383
## [19] train-rmse:1.715310 test-rmse:1.670209
## [20] train-rmse:1.672044 test-rmse:1.624511
## [21] train-rmse:1.635366 test-rmse:1.586885
## [22] train-rmse:1.601085 test-rmse:1.552493
## [23] train-rmse:1.571411 test-rmse:1.523751
## [24] train-rmse:1.543327 test-rmse:1.495741
## [25] train-rmse:1.518790 test-rmse:1.470045
## [26] train-rmse:1.495421 test-rmse:1.446694
## [27] train-rmse:1.475356 test-rmse:1.425706
## [28] train-rmse:1.455188 test-rmse:1.406342
## [29] train-rmse:1.437881 test-rmse:1.388505
## [30] train-rmse:1.422261 test-rmse:1.372046
## [31] train-rmse:1.408757 test-rmse:1.359000
## [32] train-rmse:1.397552 test-rmse:1.347399
## [33] train-rmse:1.388516 test-rmse:1.338358
## [34] train-rmse:1.379882 test-rmse:1.329643
## [35] train-rmse:1.367493 test-rmse:1.316407
## [36] train-rmse:1.359725 test-rmse:1.308389
## [37] train-rmse:1.353133 test-rmse:1.301380
## [38] train-rmse:1.342213 test-rmse:1.290771
## [39] train-rmse:1.333939 test-rmse:1.282504
## [40] train-rmse:1.322911 test-rmse:1.270202
## [41] train-rmse:1.317015 test-rmse:1.263745
## [42] train-rmse:1.311355 test-rmse:1.258621
## [43] train-rmse:1.304130 test-rmse:1.251296
## [44] train-rmse:1.296515 test-rmse:1.244013
## [45] train-rmse:1.288016 test-rmse:1.235485
## [46] train-rmse:1.284544 test-rmse:1.231519
## [47] train-rmse:1.279014 test-rmse:1.226407
## [48] train-rmse:1.273328 test-rmse:1.220318
## [49] train-rmse:1.268399 test-rmse:1.214850
## [50] train-rmse:1.258813 test-rmse:1.204619
## [51] train-rmse:1.254298 test-rmse:1.199854
## [52] train-rmse:1.249325 test-rmse:1.194856
## [53] train-rmse:1.245793 test-rmse:1.191412
## [54] train-rmse:1.241816 test-rmse:1.187454
## [55] train-rmse:1.239455 test-rmse:1.185362
## [56] train-rmse:1.234452 test-rmse:1.181023
## [57] train-rmse:1.232270 test-rmse:1.178320
## [58] train-rmse:1.231153 test-rmse:1.177559
## [59] train-rmse:1.229061 test-rmse:1.175881
## [60] train-rmse:1.225523 test-rmse:1.172139
## [61] train-rmse:1.221330 test-rmse:1.168194
## [62] train-rmse:1.219580 test-rmse:1.166551
## [63] train-rmse:1.214482 test-rmse:1.162596
## [64] train-rmse:1.210475 test-rmse:1.158882
## [65] train-rmse:1.207346 test-rmse:1.156511
## [66] train-rmse:1.205369 test-rmse:1.153988
## [67] train-rmse:1.201089 test-rmse:1.150432
## [68] train-rmse:1.197651 test-rmse:1.146894
## [69] train-rmse:1.194386 test-rmse:1.143690
## [70] train-rmse:1.192083 test-rmse:1.141408
## [71] train-rmse:1.189401 test-rmse:1.139332
## [72] train-rmse:1.188164 test-rmse:1.138204
## [73] train-rmse:1.185176 test-rmse:1.136246
## [74] train-rmse:1.184499 test-rmse:1.135748
## [75] train-rmse:1.182506 test-rmse:1.133921
## [76] train-rmse:1.180092 test-rmse:1.131723
## [77] train-rmse:1.178299 test-rmse:1.129266
## [78] train-rmse:1.175901 test-rmse:1.126932
## [79] train-rmse:1.174902 test-rmse:1.126238
## [80] train-rmse:1.173281 test-rmse:1.124637
## [81] train-rmse:1.169641 test-rmse:1.121270
## [82] train-rmse:1.168007 test-rmse:1.120182
## [83] train-rmse:1.163172 test-rmse:1.115692
## [84] train-rmse:1.158854 test-rmse:1.111909
## [85] train-rmse:1.155611 test-rmse:1.109203
## [86] train-rmse:1.152746 test-rmse:1.106630
## [87] train-rmse:1.149361 test-rmse:1.102944
## [88] train-rmse:1.146411 test-rmse:1.100112
## [89] train-rmse:1.144814 test-rmse:1.098647
## [90] train-rmse:1.139972 test-rmse:1.093068
## [91] train-rmse:1.138213 test-rmse:1.091491
## [92] train-rmse:1.133734 test-rmse:1.087076
## [93] train-rmse:1.130183 test-rmse:1.084084
## [94] train-rmse:1.125750 test-rmse:1.078923
## [95] train-rmse:1.122755 test-rmse:1.076698
## [96] train-rmse:1.119065 test-rmse:1.072559
## [97] train-rmse:1.116044 test-rmse:1.069399
## [98] train-rmse:1.112321 test-rmse:1.066132
## [99] train-rmse:1.109467 test-rmse:1.063829
## [100]    train-rmse:1.107287 test-rmse:1.061993
## [101]    train-rmse:1.105556 test-rmse:1.060501
## [102]    train-rmse:1.102753 test-rmse:1.056482
## [103]    train-rmse:1.100359 test-rmse:1.054304
## [104]    train-rmse:1.098308 test-rmse:1.052449
## [105]    train-rmse:1.096340 test-rmse:1.050071
## [106]    train-rmse:1.094346 test-rmse:1.048479
## [107]    train-rmse:1.089995 test-rmse:1.044490
## [108]    train-rmse:1.088851 test-rmse:1.043283
## [109]    train-rmse:1.085375 test-rmse:1.039856
## [110]    train-rmse:1.081202 test-rmse:1.036354
## [111]    train-rmse:1.078739 test-rmse:1.033474
## [112]    train-rmse:1.074086 test-rmse:1.029593
## [113]    train-rmse:1.070534 test-rmse:1.025988
## [114]    train-rmse:1.067094 test-rmse:1.023349
## [115]    train-rmse:1.065543 test-rmse:1.021735
## [116]    train-rmse:1.061059 test-rmse:1.017380
## [117]    train-rmse:1.058037 test-rmse:1.014292
## [118]    train-rmse:1.056143 test-rmse:1.012086
## [119]    train-rmse:1.054986 test-rmse:1.011330
## [120]    train-rmse:1.052443 test-rmse:1.009112
## [121]    train-rmse:1.050371 test-rmse:1.006881
## [122]    train-rmse:1.048889 test-rmse:1.005309
## [123]    train-rmse:1.046473 test-rmse:1.002869
## [124]    train-rmse:1.045085 test-rmse:1.001402
## [125]    train-rmse:1.043980 test-rmse:1.000072
## [126]    train-rmse:1.041901 test-rmse:0.998864
## [127]    train-rmse:1.041125 test-rmse:0.998482
## [128]    train-rmse:1.037061 test-rmse:0.995028
## [129]    train-rmse:1.034588 test-rmse:0.992739
## [130]    train-rmse:1.032864 test-rmse:0.991188
## [131]    train-rmse:1.030819 test-rmse:0.989549
## [132]    train-rmse:1.026703 test-rmse:0.985955
## [133]    train-rmse:1.024732 test-rmse:0.984038
## [134]    train-rmse:1.023262 test-rmse:0.982202
## [135]    train-rmse:1.018881 test-rmse:0.978220
## [136]    train-rmse:1.017364 test-rmse:0.976723
## [137]    train-rmse:1.015483 test-rmse:0.974993
## [138]    train-rmse:1.013167 test-rmse:0.972763
## [139]    train-rmse:1.011353 test-rmse:0.971544
## [140]    train-rmse:1.009608 test-rmse:0.969869
## [141]    train-rmse:1.006566 test-rmse:0.966828
## [142]    train-rmse:1.004525 test-rmse:0.964876
## [143]    train-rmse:1.003655 test-rmse:0.963932
## [144]    train-rmse:1.000628 test-rmse:0.960524
## [145]    train-rmse:0.996676 test-rmse:0.956816
## [146]    train-rmse:0.996098 test-rmse:0.956127
## [147]    train-rmse:0.994228 test-rmse:0.954639
## [148]    train-rmse:0.990461 test-rmse:0.950914
## [149]    train-rmse:0.989735 test-rmse:0.949812
## [150]    train-rmse:0.986842 test-rmse:0.947797
## [151]    train-rmse:0.984686 test-rmse:0.945694
## [152]    train-rmse:0.983000 test-rmse:0.944108
## [153]    train-rmse:0.981099 test-rmse:0.943231
## [154]    train-rmse:0.979203 test-rmse:0.941475
## [155]    train-rmse:0.977992 test-rmse:0.940297
## [156]    train-rmse:0.975571 test-rmse:0.938265
## [157]    train-rmse:0.973738 test-rmse:0.937037
## [158]    train-rmse:0.972491 test-rmse:0.936013
## [159]    train-rmse:0.970570 test-rmse:0.934623
## [160]    train-rmse:0.968296 test-rmse:0.932594
## [161]    train-rmse:0.966147 test-rmse:0.930525
## [162]    train-rmse:0.964317 test-rmse:0.928835
## [163]    train-rmse:0.961000 test-rmse:0.925837
## [164]    train-rmse:0.958314 test-rmse:0.923588
## [165]    train-rmse:0.957115 test-rmse:0.922401
## [166]    train-rmse:0.955667 test-rmse:0.921388
## [167]    train-rmse:0.953721 test-rmse:0.919674
## [168]    train-rmse:0.951551 test-rmse:0.917518
## [169]    train-rmse:0.948920 test-rmse:0.914825
## [170]    train-rmse:0.946041 test-rmse:0.911841
## [171]    train-rmse:0.944416 test-rmse:0.910090
## [172]    train-rmse:0.942236 test-rmse:0.908583
## [173]    train-rmse:0.940108 test-rmse:0.907131
## [174]    train-rmse:0.937583 test-rmse:0.905099
## [175]    train-rmse:0.934673 test-rmse:0.902544
## [176]    train-rmse:0.931444 test-rmse:0.899778
## [177]    train-rmse:0.929155 test-rmse:0.897509
## [178]    train-rmse:0.927110 test-rmse:0.895793
## [179]    train-rmse:0.925310 test-rmse:0.893317
## [180]    train-rmse:0.922617 test-rmse:0.890624
## [181]    train-rmse:0.920240 test-rmse:0.888340
## [182]    train-rmse:0.917727 test-rmse:0.886257
## [183]    train-rmse:0.917253 test-rmse:0.885176
## [184]    train-rmse:0.915168 test-rmse:0.883071
## [185]    train-rmse:0.914009 test-rmse:0.882061
## [186]    train-rmse:0.912060 test-rmse:0.879808
## [187]    train-rmse:0.910786 test-rmse:0.878309
## [188]    train-rmse:0.909209 test-rmse:0.876546
## [189]    train-rmse:0.906328 test-rmse:0.873930
## [190]    train-rmse:0.904873 test-rmse:0.872574
## [191]    train-rmse:0.903459 test-rmse:0.871795
## [192]    train-rmse:0.901217 test-rmse:0.869510
## [193]    train-rmse:0.900317 test-rmse:0.868433
## [194]    train-rmse:0.897286 test-rmse:0.865145
## [195]    train-rmse:0.895694 test-rmse:0.863634
## [196]	train-rmse:0.893252 test-rmse:0.861141
## [197]	train-rmse:0.891820 test-rmse:0.859649
## [198]	train-rmse:0.889220 test-rmse:0.857219
## [199]	train-rmse:0.887201 test-rmse:0.855087
## [200]	train-rmse:0.885379 test-rmse:0.853104
## [201]	train-rmse:0.883429 test-rmse:0.851252
## [202]	train-rmse:0.880177 test-rmse:0.848152
## [203]	train-rmse:0.877390 test-rmse:0.845695
## [204]	train-rmse:0.875623 test-rmse:0.843846
## [205]	train-rmse:0.873801 test-rmse:0.842558
## [206]	train-rmse:0.872103 test-rmse:0.841085
## [207]	train-rmse:0.870265 test-rmse:0.839578
## [208]	train-rmse:0.867292 test-rmse:0.836386
## [209]	train-rmse:0.865211 test-rmse:0.834793
## [210]	train-rmse:0.863276 test-rmse:0.832697
## [211]	train-rmse:0.861271 test-rmse:0.830880
## [212]	train-rmse:0.859940 test-rmse:0.829544
## [213]	train-rmse:0.859224 test-rmse:0.829109
## [214]	train-rmse:0.857888 test-rmse:0.827842
## [215]	train-rmse:0.854748 test-rmse:0.825048
## [216]	train-rmse:0.852002 test-rmse:0.822409
## [217]	train-rmse:0.851176 test-rmse:0.821815
## [218]	train-rmse:0.848915 test-rmse:0.819978
## [219]	train-rmse:0.848028 test-rmse:0.819173
## [220]	train-rmse:0.845899 test-rmse:0.816902
## [221]	train-rmse:0.844716 test-rmse:0.815932
## [222]	train-rmse:0.843605 test-rmse:0.814764
## [223]	train-rmse:0.841525 test-rmse:0.812600
## [224]	train-rmse:0.839547 test-rmse:0.810486
## [225]	train-rmse:0.839069 test-rmse:0.809784
## [226]	train-rmse:0.838444 test-rmse:0.809556
## [227]	train-rmse:0.837312 test-rmse:0.808728
## [228]	train-rmse:0.835741 test-rmse:0.807316
## [229]	train-rmse:0.832590 test-rmse:0.803250
## [230]	train-rmse:0.831374 test-rmse:0.801845
## [231]	train-rmse:0.830644 test-rmse:0.801284
## [232]	train-rmse:0.829371 test-rmse:0.800198
## [233]	train-rmse:0.826785 test-rmse:0.797554
## [234]	train-rmse:0.824094 test-rmse:0.795110
## [235]	train-rmse:0.822027 test-rmse:0.793180
## [236]	train-rmse:0.820409 test-rmse:0.792139
## [237]	train-rmse:0.819674 test-rmse:0.791502
## [238]	train-rmse:0.816972 test-rmse:0.789010
## [239]	train-rmse:0.813988 test-rmse:0.785863
## [240]	train-rmse:0.811312 test-rmse:0.782388
## [241]	train-rmse:0.809783 test-rmse:0.781024
## [242]	train-rmse:0.808563 test-rmse:0.780011
## [243]	train-rmse:0.806094 test-rmse:0.777335
## [244]	train-rmse:0.805237 test-rmse:0.776654
## [245]	train-rmse:0.803634 test-rmse:0.774829
## [246]	train-rmse:0.802519 test-rmse:0.773635
## [247]	train-rmse:0.801826 test-rmse:0.773010
## [248]	train-rmse:0.800675 test-rmse:0.772095
## [249]	train-rmse:0.799914 test-rmse:0.771179
## [250]    train-rmse:0.797308 test-rmse:0.768417
## [251]    train-rmse:0.796316 test-rmse:0.767352
## [252]    train-rmse:0.793856 test-rmse:0.764653
## [253]    train-rmse:0.791743 test-rmse:0.762567
## [254]    train-rmse:0.791003 test-rmse:0.762301
## [255]    train-rmse:0.788942 test-rmse:0.760139
## [256]    train-rmse:0.787742 test-rmse:0.759070
## [257]    train-rmse:0.785927 test-rmse:0.757486
## [258]    train-rmse:0.784754 test-rmse:0.756090
## [259]    train-rmse:0.782362 test-rmse:0.754039
## [260]    train-rmse:0.781914 test-rmse:0.753921
## [261]    train-rmse:0.780094 test-rmse:0.752691
## [262]    train-rmse:0.778729 test-rmse:0.751268
## [263]    train-rmse:0.777914 test-rmse:0.750506
## [264]    train-rmse:0.776727 test-rmse:0.749233
## [265]    train-rmse:0.775825 test-rmse:0.748148
## [266]    train-rmse:0.774760 test-rmse:0.746664
## [267]    train-rmse:0.773697 test-rmse:0.745456
## [268]    train-rmse:0.771832 test-rmse:0.743622
## [269]    train-rmse:0.770925 test-rmse:0.742817
## [270]    train-rmse:0.769148 test-rmse:0.741065
## [271]    train-rmse:0.768176 test-rmse:0.740123
## [272]    train-rmse:0.766237 test-rmse:0.738491
## [273]    train-rmse:0.764522 test-rmse:0.737412
## [274]    train-rmse:0.762812 test-rmse:0.735759
## [275]    train-rmse:0.761861 test-rmse:0.734821
## [276]    train-rmse:0.760164 test-rmse:0.733243
## [277]    train-rmse:0.759159 test-rmse:0.732434
## [278]    train-rmse:0.757191 test-rmse:0.731053
## [279]    train-rmse:0.755587 test-rmse:0.729759
## [280]    train-rmse:0.755069 test-rmse:0.729026
## [281]    train-rmse:0.753662 test-rmse:0.727610
## [282]    train-rmse:0.752893 test-rmse:0.727072
## [283]    train-rmse:0.751385 test-rmse:0.725269
## [284]    train-rmse:0.749377 test-rmse:0.723055
## [285]    train-rmse:0.748174 test-rmse:0.722082
## [286]    train-rmse:0.745949 test-rmse:0.719420
## [287]    train-rmse:0.744206 test-rmse:0.717980
## [288]    train-rmse:0.742439 test-rmse:0.715931
## [289]    train-rmse:0.741046 test-rmse:0.714538
## [290]    train-rmse:0.739363 test-rmse:0.713380
## [291]    train-rmse:0.737168 test-rmse:0.711460
## [292]    train-rmse:0.736599 test-rmse:0.710968
## [293]    train-rmse:0.735962 test-rmse:0.710670
## [294]    train-rmse:0.734826 test-rmse:0.709442
## [295]    train-rmse:0.732746 test-rmse:0.707165
## [296]    train-rmse:0.731869 test-rmse:0.706218
## [297]    train-rmse:0.729721 test-rmse:0.704300
## [298]    train-rmse:0.728602 test-rmse:0.702930
## [299]    train-rmse:0.727531 test-rmse:0.701806
## [300]    train-rmse:0.726580 test-rmse:0.701164
## [301]    train-rmse:0.725858 test-rmse:0.700388
## [302]    train-rmse:0.723688 test-rmse:0.698384
## [303]    train-rmse:0.722609 test-rmse:0.697215
## [304]    train-rmse:0.720867 test-rmse:0.695499
## [305]    train-rmse:0.718701 test-rmse:0.693353
## [306]    train-rmse:0.717462 test-rmse:0.692163
## [307]    train-rmse:0.716301 test-rmse:0.690820
## [308]    train-rmse:0.715236 test-rmse:0.689755
## [309]    train-rmse:0.713692 test-rmse:0.688536
## [310]    train-rmse:0.711912 test-rmse:0.687019
## [311]    train-rmse:0.710193 test-rmse:0.685679
## [312]    train-rmse:0.708828 test-rmse:0.684483
## [313]    train-rmse:0.706941 test-rmse:0.683460
## [314]    train-rmse:0.706054 test-rmse:0.682891
## [315]    train-rmse:0.704536 test-rmse:0.681564
## [316]    train-rmse:0.703495 test-rmse:0.680323
## [317]    train-rmse:0.701973 test-rmse:0.678425
## [318]    train-rmse:0.701423 test-rmse:0.677875
## [319]    train-rmse:0.700126 test-rmse:0.676354
## [320]    train-rmse:0.698831 test-rmse:0.675106
## [321]    train-rmse:0.697991 test-rmse:0.674364
## [322]    train-rmse:0.697307 test-rmse:0.673758
## [323]    train-rmse:0.695968 test-rmse:0.672263
## [324]    train-rmse:0.693881 test-rmse:0.670520
## [325]    train-rmse:0.692684 test-rmse:0.669381
## [326]    train-rmse:0.691881 test-rmse:0.668464
## [327]    train-rmse:0.690134 test-rmse:0.666395
## [328]    train-rmse:0.689142 test-rmse:0.665403
## [329]    train-rmse:0.688552 test-rmse:0.664810
## [330]    train-rmse:0.687817 test-rmse:0.663949
## [331]    train-rmse:0.686416 test-rmse:0.662535
## [332]    train-rmse:0.685160 test-rmse:0.661403
## [333]    train-rmse:0.684440 test-rmse:0.661207
## [334]    train-rmse:0.682171 test-rmse:0.659004
## [335]    train-rmse:0.681422 test-rmse:0.658293
## [336]    train-rmse:0.679171 test-rmse:0.656031
## [337]    train-rmse:0.678338 test-rmse:0.655335
## [338]    train-rmse:0.677026 test-rmse:0.654340
## [339]    train-rmse:0.676225 test-rmse:0.653193
## [340]    train-rmse:0.675391 test-rmse:0.652304
## [341]    train-rmse:0.674465 test-rmse:0.651662
## [342]    train-rmse:0.673067 test-rmse:0.650478
## [343]    train-rmse:0.671717 test-rmse:0.649411
## [344]    train-rmse:0.670406 test-rmse:0.648445
## [345]    train-rmse:0.669932 test-rmse:0.647897
## [346]    train-rmse:0.669593 test-rmse:0.647181
## [347]    train-rmse:0.668158 test-rmse:0.646252
## [348]    train-rmse:0.666871 test-rmse:0.645021
## [349]    train-rmse:0.665404 test-rmse:0.643485
## [350]    train-rmse:0.664445 test-rmse:0.642162
## [351]    train-rmse:0.662282 test-rmse:0.640471
## [352]    train-rmse:0.660002 test-rmse:0.638387
## [353]    train-rmse:0.658524 test-rmse:0.636852
## [354]    train-rmse:0.657514 test-rmse:0.635983
## [355]    train-rmse:0.656485 test-rmse:0.635134
## [356]    train-rmse:0.655182 test-rmse:0.633924
## [357]    train-rmse:0.653995 test-rmse:0.632798
## [358]	train-rmse:0.652017 test-rmse:0.631039
## [359]	train-rmse:0.650585 test-rmse:0.629556
## [360]	train-rmse:0.649632 test-rmse:0.628392
## [361]	train-rmse:0.648926 test-rmse:0.627745
## [362]	train-rmse:0.647813 test-rmse:0.626550
## [363]	train-rmse:0.646688 test-rmse:0.625370
## [364]	train-rmse:0.645548 test-rmse:0.624341
## [365]	train-rmse:0.644513 test-rmse:0.623121
## [366]	train-rmse:0.643884 test-rmse:0.622650
## [367]	train-rmse:0.642333 test-rmse:0.621182
## [368]	train-rmse:0.640275 test-rmse:0.619074
## [369]	train-rmse:0.638806 test-rmse:0.617434
## [370]	train-rmse:0.638023 test-rmse:0.616571
## [371]	train-rmse:0.637346 test-rmse:0.616132
## [372]	train-rmse:0.636063 test-rmse:0.614996
## [373]	train-rmse:0.634696 test-rmse:0.613879
## [374]	train-rmse:0.634312 test-rmse:0.613464
## [375]	train-rmse:0.633438 test-rmse:0.612745
## [376]	train-rmse:0.632294 test-rmse:0.611645
## [377]	train-rmse:0.631493 test-rmse:0.611028
## [378]	train-rmse:0.630599 test-rmse:0.610184
## [379]	train-rmse:0.629387 test-rmse:0.609031
## [380]	train-rmse:0.627147 test-rmse:0.606702
## [381]	train-rmse:0.625359 test-rmse:0.604632
## [382]	train-rmse:0.623860 test-rmse:0.602966
## [383]	train-rmse:0.622682 test-rmse:0.602075
## [384]	train-rmse:0.621585 test-rmse:0.601282
## [385]	train-rmse:0.620168 test-rmse:0.599974
## [386]	train-rmse:0.618488 test-rmse:0.598457
## [387]	train-rmse:0.617000 test-rmse:0.597154
## [388]	train-rmse:0.615617 test-rmse:0.595611
## [389]	train-rmse:0.614860 test-rmse:0.594907
## [390]	train-rmse:0.614022 test-rmse:0.594117
## [391]	train-rmse:0.613195 test-rmse:0.593231
## [392]	train-rmse:0.611820 test-rmse:0.591842
## [393]	train-rmse:0.610731 test-rmse:0.590898
## [394]	train-rmse:0.609356 test-rmse:0.589679
## [395]	train-rmse:0.608451 test-rmse:0.588467
## [396]	train-rmse:0.607173 test-rmse:0.587559
## [397]	train-rmse:0.606470 test-rmse:0.586718
## [398]	train-rmse:0.605244 test-rmse:0.585830
## [399]	train-rmse:0.604646 test-rmse:0.585342
## [400]	train-rmse:0.603530 test-rmse:0.584198
## [401]	train-rmse:0.602623 test-rmse:0.583399
## [402]	train-rmse:0.601329 test-rmse:0.582330
## [403]	train-rmse:0.600210 test-rmse:0.581235
## [404]	train-rmse:0.598853 test-rmse:0.579847
## [405]	train-rmse:0.596860 test-rmse:0.578320
## [406]	train-rmse:0.595422 test-rmse:0.577435
## [407]	train-rmse:0.593431 test-rmse:0.575863
## [408]	train-rmse:0.593126 test-rmse:0.575553
## [409]	train-rmse:0.592376 test-rmse:0.575015
## [410]	train-rmse:0.591463 test-rmse:0.574083
## [411]	train-rmse:0.589531 test-rmse:0.572187
## [412]	train-rmse:0.588435 test-rmse:0.570693
## [413]	train-rmse:0.587846 test-rmse:0.570172
## [414]	train-rmse:0.586840 test-rmse:0.569250
## [415]	train-rmse:0.585770 test-rmse:0.568249
## [416]	train-rmse:0.584600 test-rmse:0.567228
## [417]	train-rmse:0.584084 test-rmse:0.566800
## [418]	train-rmse:0.582976 test-rmse:0.565719
## [419]	train-rmse:0.581313 test-rmse:0.564447
## [420]	train-rmse:0.580380 test-rmse:0.563696
## [421]	train-rmse:0.579559 test-rmse:0.562839
## [422]	train-rmse:0.579214 test-rmse:0.562393
## [423]	train-rmse:0.577814 test-rmse:0.561148
## [424]	train-rmse:0.577021 test-rmse:0.560858
## [425]	train-rmse:0.576355 test-rmse:0.560080
## [426]	train-rmse:0.574804 test-rmse:0.558384
## [427]	train-rmse:0.573869 test-rmse:0.557346
## [428]	train-rmse:0.573038 test-rmse:0.556761
## [429]	train-rmse:0.572355 test-rmse:0.556224
## [430]	train-rmse:0.571549 test-rmse:0.555790
## [431]	train-rmse:0.569792 test-rmse:0.554863
## [432]	train-rmse:0.567914 test-rmse:0.552897
## [433]	train-rmse:0.567219 test-rmse:0.552094
## [434]	train-rmse:0.566593 test-rmse:0.551508
## [435]	train-rmse:0.565767 test-rmse:0.550911
## [436]	train-rmse:0.564675 test-rmse:0.549855
## [437]	train-rmse:0.563199 test-rmse:0.548549
## [438]	train-rmse:0.561372 test-rmse:0.546901
## [439]	train-rmse:0.560999 test-rmse:0.546519
## [440]	train-rmse:0.559456 test-rmse:0.545209
## [441]	train-rmse:0.558581 test-rmse:0.543814
## [442]	train-rmse:0.557518 test-rmse:0.542661
## [443]	train-rmse:0.557074 test-rmse:0.542170
## [444]	train-rmse:0.556146 test-rmse:0.541380
## [445]	train-rmse:0.555155 test-rmse:0.540288
## [446]	train-rmse:0.553837 test-rmse:0.539421
## [447]	train-rmse:0.552988 test-rmse:0.538543
## [448]	train-rmse:0.552013 test-rmse:0.537776
## [449]	train-rmse:0.550649 test-rmse:0.536452
## [450]	train-rmse:0.548762 test-rmse:0.534509
## [451]	train-rmse:0.547439 test-rmse:0.533513
## [452]	train-rmse:0.546387 test-rmse:0.532687
## [453]	train-rmse:0.545457 test-rmse:0.532068
## [454]	train-rmse:0.544534 test-rmse:0.530893
## [455]	train-rmse:0.543255 test-rmse:0.529659
## [456]	train-rmse:0.541367 test-rmse:0.527945
## [457]	train-rmse:0.540737 test-rmse:0.527491
## [458]	train-rmse:0.539623 test-rmse:0.526348
## [459]	train-rmse:0.538655 test-rmse:0.525779
## [460]	train-rmse:0.538069 test-rmse:0.524983
## [461]	train-rmse:0.536708 test-rmse:0.523665
## [462]	train-rmse:0.536271 test-rmse:0.523052
## [463]	train-rmse:0.534859 test-rmse:0.521834
## [464]	train-rmse:0.533615 test-rmse:0.520462
## [465]	train-rmse:0.531947 test-rmse:0.518454
## [466]    train-rmse:0.531182 test-rmse:0.517446
## [467]    train-rmse:0.529546 test-rmse:0.515821
## [468]    train-rmse:0.529032 test-rmse:0.515244
## [469]    train-rmse:0.528007 test-rmse:0.513993
## [470]    train-rmse:0.526712 test-rmse:0.512654
## [471]    train-rmse:0.526046 test-rmse:0.511996
## [472]    train-rmse:0.525831 test-rmse:0.511723
## [473]    train-rmse:0.524558 test-rmse:0.510507
## [474]    train-rmse:0.524217 test-rmse:0.510266
## [475]    train-rmse:0.523509 test-rmse:0.509481
## [476]    train-rmse:0.522930 test-rmse:0.508750
## [477]    train-rmse:0.522051 test-rmse:0.508069
## [478]    train-rmse:0.520685 test-rmse:0.506886
## [479]    train-rmse:0.519806 test-rmse:0.505778
## [480]    train-rmse:0.519411 test-rmse:0.505310
## [481]    train-rmse:0.518468 test-rmse:0.504231
## [482]    train-rmse:0.517312 test-rmse:0.503379
## [483]    train-rmse:0.516010 test-rmse:0.502314
## [484]    train-rmse:0.515130 test-rmse:0.501371
## [485]    train-rmse:0.514165 test-rmse:0.500735
## [486]    train-rmse:0.513298 test-rmse:0.499875
## [487]    train-rmse:0.512533 test-rmse:0.499175
## [488]    train-rmse:0.511941 test-rmse:0.498510
## [489]    train-rmse:0.510847 test-rmse:0.497240
## [490]    train-rmse:0.509866 test-rmse:0.496288
## [491]    train-rmse:0.508944 test-rmse:0.495558
## [492]    train-rmse:0.508756 test-rmse:0.495413
## [493]    train-rmse:0.508055 test-rmse:0.494781
## [494]    train-rmse:0.507188 test-rmse:0.493545
## [495]    train-rmse:0.506118 test-rmse:0.492404
## [496]    train-rmse:0.504300 test-rmse:0.490865
## [497]    train-rmse:0.503278 test-rmse:0.489977
## [498]    train-rmse:0.502358 test-rmse:0.488780
## [499]    train-rmse:0.501250 test-rmse:0.487799
## [500]    train-rmse:0.500933 test-rmse:0.487536
```

Variable importance

```
xgb.plot.shap(data=trainm,model=xgb_fit,top_n=5)
```



## Validate

```
valid_p <- predict(xgb_fit,valid_matrix)
xgb_RMSE <- RMSE(valid_p, valid$growth_2_6)
xgb_RMSE # validation RMSE
```

```
## [1] 0.4875357
```

```
valid_preds <- data.frame("obs"=valid$growth_2_6, "pred"=valid_p)
head(valid_preds,10) # check predictions
```

```
##          obs     pred
## 1  3.002473 3.711255
## 2  5.000000 5.355220
## 3  1.932232 2.687959
## 4  6.365432 6.046679
## 5  7.833333 7.839030
## 6  6.597612 6.407967
## 7  2.527267 2.592344
## 8  2.244444 2.094875
## 9  4.231683 3.625521
## 10 4.536059 3.837349
```

Predict on Test

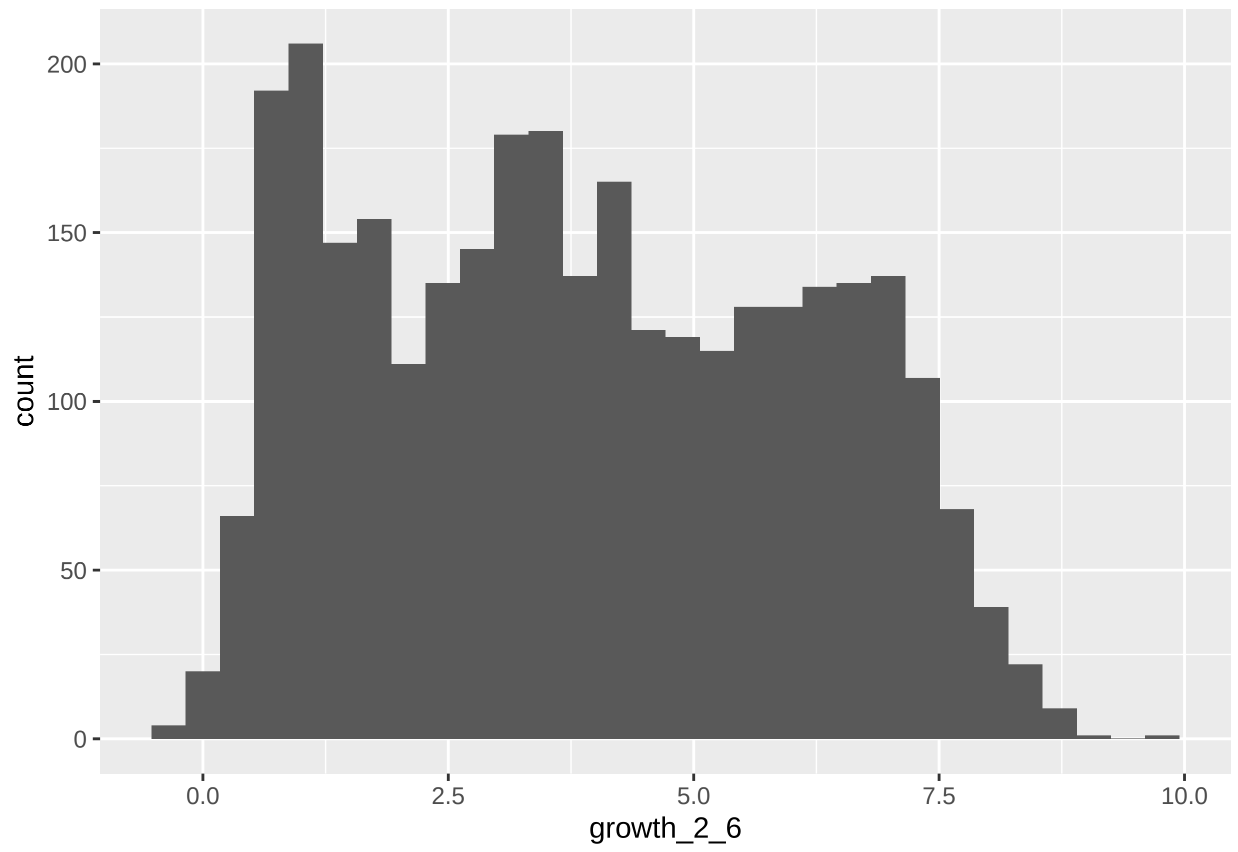
```
# format test for XGB
test <- test[subset]
testm <- as.matrix(test)
```

```r
dtest <- xgb.DMatrix(data = testm)
# make prediction
preds <- predict(xgb_fit,newdata = dtest)
df <- data.frame("id" = test_id, "growth_2_6" = preds)
head(df)
```

```
##     id growth_2_6
## 1 7242   5.984253
## 2 7243   2.693341
## 3 7244   1.513965
## 4 7245   7.111295
## 5 7246   4.837350
## 6 7247   2.732717
```

```r
# check distribution of predictions
ggplot(df) + geom_histogram(aes(x=growth_2_6))
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



## Write to csv

```r
write.csv(df,"sub_4f.csv", row.names = FALSE)
```