Classifier

```r
set.seed(42)

library(caret) # highly correlated features removal
```

```
## Loading required package: ggplot2

## Loading required package: lattice
```

```r
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## v forcats   1.0.0     v stringr   1.5.1
## v lubridate 1.9.3     v tibble    3.2.1
## v purrr     1.0.2     v tidyr     1.3.1

## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## x purrr::lift()   masks caret::lift()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become error
```

```r
library(tidymodels)
```

```
## -- Attaching packages -------------------------------------- tidymodels 1.2.0 --
## v broom        1.0.5     v rsample      1.2.1
## v dials        1.3.0     v tune         1.2.1
## v infer        1.0.7     v workflows    1.1.4
## v modeldata    1.4.0     v workflowsets 1.1.0
## v parsnip      1.2.1     v yardstick    1.3.2
## v recipes      1.1.0
## -- Conflicts ----------------------------------------- tidymodels_conflicts() --
## x scales::discard()        masks purrr::discard()
## x dplyr::filter()          masks stats::filter()
## x recipes::fixed()         masks stringr::fixed()
## x dplyr::lag()             masks stats::lag()
## x purrr::lift()            masks caret::lift()
## x yardstick::precision()   masks caret::precision()
## x yardstick::recall()      masks caret::recall()
## x yardstick::sensitivity() masks caret::sensitivity()
## x yardstick::spec()        masks readr::spec()
## x yardstick::specificity() masks caret::specificity()
## x recipes::step()          masks stats::step()
## * Search for functions across packages at https://www.tidymodels.org/find/
```

```r
library(e1071)
```

```
##
## Attaching package: 'e1071'
##
```

```
## The following object is masked from 'package:tune':
##
##     tune
##
## The following object is masked from 'package:rsample':
##
##     permutations
##
## The following object is masked from 'package:parsnip':
##
##     tune
```

Helpers

```r
train_svm <- function(
    training_set,
    testing_set,
    columns,
    kernel = "radial",
    gamma = if (is.vector(training_set)) 1 else 1 / ncol(training_set),
    cost = 1) {
  model <- svm(
    training_set[columns],
    training_set$class,
    kernel = kernel, type = "C-classification",
    gamma = gamma,
    cost = cost,
    probability = TRUE,
    cross = 10
  )

  if (is.null(testing_set)) {
    return(list(
      model = model
    ))
  }

  pred <- predict(model, testing_set[columns], probability = TRUE)
  set_with_preds <- testing_set %>%
    mutate(
      pred = pred,
      prob_good = attr(pred, "probabilities")[, "good"],
      prob_bad = attr(pred, "probabilities")[, "bad"]
    )

  cm <- confusionMatrix(
    set_with_preds$pred, set_with_preds$class,
    mode = "everything"
  )

  return(list(
    model = model,
    prediction_set = set_with_preds,
    cm = cm
  ))
}

train_glm <- function(training_set, testing_set, columns) {
  formula <- reformulate(colnames(training_set[columns]), "class")
  model <- glm(
    formula,
    training_set,
    family = "binomial"
  )
  pred <- predict(model, testing_set[columns], type = "response")
  set_with_preds <- testing_set %>%
    mutate(
      prob_good = pred,
      prob_bad = 1 - pred,
      pred = if_else(pred > .5, "good", "bad") %>%
        factor(levels = c("bad", "good"))
    )

  cm <- confusionMatrix(
    set_with_preds$pred, set_with_preds$class,
    mode = "everything"
  )

  return(list(
    model = model,
    prediction_set = set_with_preds,
    cm = cm
  ))
}

get_mismatch_details <- function(data_with_predictions) {
  plot <- data_with_predictions %>%
    ggplot(aes(x = prob_good, y = class, color = subcorpus)) +
    geom_jitter(height = 0.2, width = 0)
  print(plot)

  cat("Confusion matrices by subcorpora:\n")
  data_with_predictions %>%
    select(pred, class, subcorpus) %>%
    table() %>%
    print()

  cat("\n")

  deviations <- data_with_predictions %>%
    filter(pred != class) %>%
    mutate(abs_dev = abs(prob_good - 0.5)) %>%
    arrange(-abs_dev)

  cat("Greatest deviations:\n")
  deviations %>%
    select(abs_dev, prob_good, class, subcorpus, FileName) %>%
    mutate(across(c(prob_good, abs_dev), ~ round(.x, 3))) %>%
    print(n = round(nrow(data_with_predictions) / 5))

  cat("Names of highest-deviating documents:\n")
  highest_deviation_names <- deviations %>%
    filter(abs_dev >= 0.17) %>%
    arrange(-abs_dev) %>%
    pull(FileName)

  print(highest_deviation_names)

  return(list(
    deviations = deviations,
    highest_deviations = highest_deviation_names,
    plot = plot
  ))
}

plot_outlier <- function(doc_name, variable_importances, dataset) {
  important_variables <- sort(variable_importances, decreasing = TRUE) %>%
    head(n = 16)
  varnames <- names(important_variables)

  dmut <- dataset %>%
    select(KUK_ID, FileName, class, all_of(varnames)) %>%
    mutate(across(all_of(varnames), ~ scale(.x))) %>%
    pivot_longer(
      all_of(varnames),
      names_to = "feature", values_to = "value"
    ) %>%
    mutate(across(value, ~ .x[, 1])) %>%
    mutate(across(feature, ~ factor(.x, levels = varnames)))

  cat(
    nrow(dmut %>% filter(value > 5)),
    "observation(s) removed from the plot\n"
  )
  dmutf <- dmut %>% filter(value <= 5)

  plot <- dmutf %>%
    ggplot(aes(x = class, y = value)) +
    facet_wrap(~feature) +
    geom_boxplot() +
    geom_point(
      data = dmut %>% filter(FileName == doc_name), color = "red", size = 5
    ) +
    labs(y = "measurements (scaled)")

  return(plot)
}
```

Load and tidy data

```r
pretty_names <- read_csv("../feat_name_mapping.csv")
```

```
## Rows: 85 Columns: 2
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (2): name_orig, name_pretty
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```r
prettify_feat_name <- function(x) {
  name <- pull(pretty_names %>%
    filter(name_orig == x), name_pretty)
  if (length(name) == 1) {
    return(name)
  } else {
    return(x)
  }
}

prettify_feat_name_vector <- function(x) {
  map(
    x,
    prettify_feat_name
  ) %>% unlist()
}


data <- read_csv("../measurements/measurements.csv")
```

```
## Rows: 753 Columns: 108
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (20): fpath, KUK_ID, FileName, FileFormat, FolderPath, subcorpus, Source...
## dbl (85): RuleAbstractNouns, RuleAmbiguousRegards, RuleAnaphoricReferences, ...
## lgl  (3): ClarityPursuit, SyllogismBased, Bindingness
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```r
.firstnonmetacolumn <- 17

data_no_nas <- data %>%
  select(!c(
    fpath,
    # KUK_ID,
    # FileName,
    FolderPath,
    # subcorpus,
    DocumentTitle,
    ClarityPursuit,
    Readability,
    SyllogismBased,
    SourceDB
  )) %>%
  # replace -1s in variation coefficients with NAs
  mutate(across(c(
    `RuleDoubleAdpos.max_allowable_distance.v`,
    `RuleTooManyNegations.max_negation_frac.v`,
    `RuleTooManyNegations.max_allowable_negations.v`,
    `RuleTooManyNominalConstructions.max_noun_frac.v`,
    `RuleTooManyNominalConstructions.max_allowable_nouns.v`,
    `RuleCaseRepetition.max_repetition_count.v`,
    `RuleCaseRepetition.max_repetition_frac.v`,
    `RulePredSubjDistance.max_distance.v`,
    `RulePredObjDistance.max_distance.v`,
    `RuleInfVerbDistance.max_distance.v`,
    `RuleMultiPartVerbs.max_distance.v`,
    `RuleLongSentences.max_length.v`,
    `RulePredAtClauseBeginning.max_order.v`,
    `mattr.v`,
    `maentropy.v`
  ), ~ na_if(.x, -1))) %>%
  # replace NAs with 0s
  replace_na(list(
    RuleGPcoordovs = 0,
    RuleGPdeverbaddr = 0,
    RuleGPpatinstr = 0,
    RuleGPdeverbsubj = 0,
    RuleGPadjective = 0,
    RuleGPpatbenperson = 0,
    RuleGPwordorder = 0,
    RuleDoubleAdpos = 0,
    RuleDoubleAdpos.max_allowable_distance.v = 0,
    RuleAmbiguousRegards = 0,
    RuleReflexivePassWithAnimSubj = 0,
    RuleTooManyNegations = 0,
    RuleTooManyNegations.max_negation_frac.v = 0,
    RuleTooManyNegations.max_allowable_negations.v = 0,
    RuleTooManyNominalConstructions.max_noun_frac.v = 0,
    RuleTooManyNominalConstructions.max_allowable_nouns.v = 0,
    RuleFunctionWordRepetition = 0,
    RuleCaseRepetition.max_repetition_count.v = 0,
    RuleCaseRepetition.max_repetition_frac.v = 0,
    RuleWeakMeaningWords = 0,
    RuleAbstractNouns = 0,
    RuleRelativisticExpressions = 0,
    RuleConfirmationExpressions = 0,
    RuleRedundantExpressions = 0,
    RuleTooLongExpressions = 0,
    RuleAnaphoricReferences = 0,
    RuleLiteraryStyle = 0,
    RulePassive = 0,
    RulePredSubjDistance = 0,
    RulePredSubjDistance.max_distance.v = 0,
    RulePredObjDistance = 0,
    RulePredObjDistance.max_distance.v = 0,
    RuleInfVerbDistance = 0,
    RuleInfVerbDistance.max_distance.v = 0,
    RuleMultiPartVerbs = 0,
    RuleMultiPartVerbs.max_distance.v = 0,
    RuleLongSentences.max_length.v = 0,
    RulePredAtClauseBeginning.max_order.v = 0,
    RuleVerbalNouns = 0,
    RuleDoubleComparison = 0,
    RuleWrongValencyCase = 0,
    RuleWrongVerbonominalCase = 0,
    RuleIncompleteConjunction = 0
  )) %>%
  # replace NAs with medians
  mutate(across(c(
    RuleDoubleAdpos.max_allowable_distance,
    RuleTooManyNegations.max_negation_frac,
    RuleTooManyNegations.max_allowable_negations,
    RulePredSubjDistance.max_distance,
    RulePredObjDistance.max_distance,
    RuleInfVerbDistance.max_distance,
    RuleMultiPartVerbs.max_distance
  ), ~ coalesce(., median(., na.rm = TRUE)))) %>%
  # merge GPs
  mutate(
    GPs = RuleGPcoordovs +
      RuleGPdeverbaddr +
      RuleGPpatinstr +
      RuleGPdeverbsubj +
      RuleGPadjective +
      RuleGPpatbenperson +
      RuleGPwordorder
  ) %>%
  select(!c(
    RuleGPcoordovs,
    RuleGPdeverbaddr,
    RuleGPpatinstr,
    RuleGPdeverbsubj,
    RuleGPadjective,
    RuleGPpatbenperson,
    RuleGPwordorder
  ))

data_clean <- data_no_nas %>%
  # norm data expected to correlate with text length
  mutate(across(c(
    GPs,
    RuleDoubleAdpos,
    RuleAmbiguousRegards,
    RuleFunctionWordRepetition,
    RuleWeakMeaningWords,
    RuleAbstractNouns,
    RuleRelativisticExpressions,
```

```r
  RuleConfirmationExpressions,
  RuleRedundantExpressions,
  RuleTooLongExpressions,
  RuleAnaphoricReferences,
  RuleLiteraryStyle,
  RulePassive,
  RuleVerbalNouns,
  RuleDoubleComparison,
  RuleWrongValencyCase,
  RuleWrongVerbonominalCase,
  RuleIncompleteConjunction,
  num_hapax,
  RuleReflexivePassWithAnimSubj,
  RuleTooManyNominalConstructions,
  RulePredSubjDistance,
  RuleMultiPartVerbs,
  RulePredAtClauseBeginning
), ~ .x / word_count)) %>%
mutate(across(c(
  RuleTooFewVerbs,
  RuleTooManyNegations,
  RuleCaseRepetition,
  RuleLongSentences,
  RulePredObjDistance,
  RuleInfVerbDistance
), ~ .x / sent_count)) %>%
# remove variables identified as text-length dependent
select(!c(
  RuleTooFewVerbs,
  RuleTooManyNegations,
  RuleTooManyNominalConstructions,
  RuleCaseRepetition,
  RuleLongSentences,
  RulePredAtClauseBeginning,
  syllab_count,
  char_count
)) %>%
# remove variables identified as unreliable
select(!c(
  RuleAmbiguousRegards,
  RuleFunctionWordRepetition,
  RuleDoubleComparison,
  RuleWrongValencyCase,
  RuleWrongVerbonominalCase
)) %>%
# remove further variables belonging to the 'acceptability' category
select(!c(RuleIncompleteConjunction)) %>%
# remove artificially limited variables
select(!c(
  RuleCaseRepetition.max_repetition_frac,
  RuleCaseRepetition.max_repetition_frac.v
)) %>%
# remove variables with too many NAs
```

```r
  select(!c(
    RuleDoubleAdpos.max_allowable_distance,
    RuleDoubleAdpos.max_allowable_distance.v
  )) %>%
  mutate(across(c(
    class,
    FileFormat,
    subcorpus,
    DocumentVersion,
    LegalActType,
    Objectivity,
    AuthorType,
    RecipientType,
    RecipientIndividuation,
    Anonymized
  ), ~ as.factor(.x)))

# no NAs should be present now
data_clean[!complete.cases(data_clean[.firstnonmetacolumn:ncol(data_clean)]), ]
```

```
## # A tibble: 0 x 77
## # i 77 variables: KUK_ID <chr>, FileName <chr>, FileFormat <fct>,
## #   subcorpus <fct>, SourceID <chr>, DocumentVersion <fct>,
## #   ParentDocumentID <chr>, LegalActType <fct>, Objectivity <fct>,
## #   Bindingness <lgl>, AuthorType <fct>, RecipientType <fct>,
## #   RecipientIndividuation <fct>, Anonymized <fct>, Recipient Type <chr>,
## #   class <fct>, RuleAbstractNouns <dbl>, RuleAnaphoricReferences <dbl>,
## #   RuleCaseRepetition.max_repetition_count <dbl>, ...
```

```r
colnames(data_clean) <- prettify_feat_name_vector(colnames(data_clean))

data_scaled <- data_clean %>%
  mutate(across(all_of(.firstnonmetacolumn:ncol(data_clean)), ~ scale(.x)[, 1]))

data_stratified <- data_scaled %>%
  unite("strata", c("class", "subcorpus"), remove = FALSE)
```

Important features identification

```r
feature_importances <- read_csv("../importance_measures/featcomp.csv")
```

```
## Rows: 61 Columns: 21
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr  (2): Variable, Sign
## dbl (15): Importance, p_value, estimate, wilcox_p, wilcox_r, kw_p, kw_chi2, ...
## lgl  (4): selected_pval, wilcox_sel, kw_sel, selected_reg
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```r
selected_features_names <- feature_importances %>%
  filter(kw_sel) %>%
  pull(Variable)

variable_importances <- feature_importances %>%
  filter(kw_sel) %>%
  pull(kw_epsilon2)
names(variable_importances) <- selected_features_names
```

Formulas

```
columns_all <- colnames(data_stratified)[
  (.firstnonmetacolumn + 1):ncol(data_stratified)
]
columns_readabilty_forms <- c("ari", "cli", "fkgl", "fre", "gf", "smog")

correlating90 <- findCorrelation(
  cor(data_stratified[columns_all]),
  cutoff = 0.9, verbose = TRUE, names = TRUE
)
```

```
## Compare row 11  and column  42 with corr  0.943
##   Means:  0.349 vs 0.174 so flagging column 11
## Compare row 42  and column  48 with corr  0.978
##   Means:  0.333 vs 0.168 so flagging column 42
## Compare row 48  and column  57 with corr  0.987
##   Means:  0.319 vs 0.163 so flagging column 48
## Compare row 57  and column  46 with corr  0.948
##   Means:  0.303 vs 0.158 so flagging column 57
## Compare row 43  and column  44 with corr  0.96
##   Means:  0.241 vs 0.154 so flagging column 43
## Compare row 60  and column  49 with corr  0.958
##   Means:  0.176 vs 0.151 so flagging column 60
## Compare row 58  and column  55 with corr  0.979
##   Means:  0.168 vs 0.151 so flagging column 58
## Compare row 50  and column  53 with corr  0.964
##   Means:  0.167 vs 0.15 so flagging column 50
## All correlations <= 0.9
```

```
columns_notcorrelating90 <- c()
for (col in columns_all) {
  if (!(col %in% correlating90)) {
    columns_notcorrelating90 <- c(columns_notcorrelating90, col)
  }
}

correlating85 <- findCorrelation(
  cor(data_stratified[columns_all]),
  cutoff = 0.85, verbose = TRUE, names = TRUE
)
```

```
## Compare row 11  and column  42 with corr  0.943
##   Means:  0.349 vs 0.174 so flagging column 11
## Compare row 42  and column  48 with corr  0.978
##   Means:  0.333 vs 0.168 so flagging column 42
## Compare row 48  and column  57 with corr  0.987
##   Means:  0.319 vs 0.163 so flagging column 48
## Compare row 57  and column  46 with corr  0.948
##   Means:  0.303 vs 0.158 so flagging column 57
## Compare row 46  and column  47 with corr  0.852
##   Means:  0.276 vs 0.154 so flagging column 46
## Compare row 28  and column  41 with corr  0.888
##   Means:  0.273 vs 0.148 so flagging column 28
## Compare row 43  and column  44 with corr  0.96
##   Means:  0.233 vs 0.145 so flagging column 43
## Compare row 60  and column  49 with corr  0.958
##   Means:  0.176 vs 0.142 so flagging column 60
## Compare row 49  and column  58 with corr  0.887
##   Means:  0.163 vs 0.141 so flagging column 49
## Compare row 58  and column  55 with corr  0.979
##   Means:  0.156 vs 0.14 so flagging column 58
## Compare row 50  and column  53 with corr  0.964
##   Means:  0.164 vs 0.139 so flagging column 50
## Compare row 54  and column  51 with corr  0.858
##   Means:  0.117 vs 0.14 so flagging column 51
## All correlations <= 0.85
```

```
columns_notcorrelating85 <- c()
for (col in columns_all) {
  if (!(col %in% correlating85)) {
    columns_notcorrelating85 <- c(columns_notcorrelating85, col)
  }
}

correlating75 <- findCorrelation(
  cor(data_stratified[columns_all]),
  cutoff = 0.75, verbose = TRUE, names = TRUE
)
```

```
## Compare row 11  and column  42 with corr  0.943
##   Means:  0.349 vs 0.174 so flagging column 11
## Compare row 42  and column  48 with corr  0.978
##   Means:  0.333 vs 0.168 so flagging column 42
## Compare row 48  and column  57 with corr  0.987
##   Means:  0.319 vs 0.163 so flagging column 48
## Compare row 57  and column  46 with corr  0.948
##   Means:  0.303 vs 0.158 so flagging column 57
## Compare row 46  and column  47 with corr  0.852
##   Means:  0.276 vs 0.154 so flagging column 46
## Compare row 28  and column  35 with corr  0.816
##   Means:  0.273 vs 0.148 so flagging column 28
## Compare row 35  and column  41 with corr  0.76
##   Means:  0.255 vs 0.144 so flagging column 35
## Compare row 41  and column  59 with corr  0.763
##   Means:  0.238 vs 0.14 so flagging column 41
## Compare row 43  and column  44 with corr  0.96
##   Means:  0.225 vs 0.137 so flagging column 43
## Compare row 56  and column  60 with corr  0.779
##   Means:  0.18 vs 0.134 so flagging column 56
## Compare row 45  and column  60 with corr  0.772
##   Means:  0.187 vs 0.132 so flagging column 45
## Compare row 60  and column  49 with corr  0.958
##   Means:  0.157 vs 0.13 so flagging column 60
## Compare row 49  and column  58 with corr  0.887
##   Means:  0.143 vs 0.129 so flagging column 49
## Compare row 58  and column  55 with corr  0.979
##   Means:  0.139 vs 0.129 so flagging column 58
## Compare row 50  and column  53 with corr  0.964
##   Means:  0.156 vs 0.128 so flagging column 50
## Compare row 54  and column  51 with corr  0.858
##   Means:  0.12 vs 0.128 so flagging column 51
## All correlations <= 0.75
```

```
columns_notcorrelating75 <- c()
for (col in columns_all) {
  if (!(col %in% correlating75)) {
    columns_notcorrelating75 <- c(columns_notcorrelating75, col)
  }
}
```

Hyperparameters

```
# colsids <- c(
#   "all", "notcorrelating90",
#   "notcorrelating85", "notcorrelating75"
# )
# colsets <- list(
#   columns_all, columns_notcorrelating90,
#   columns_notcorrelating85, columns_notcorrelating75
# )
colsids <- c("all", "readforms")
colsets <- list(columns_all, columns_readabilty_forms)
```

Splits and folds

```
.splitprop <- 3 / 4

split <- initial_split(data_stratified, .splitprop, strata = strata)

training_set <- training(split)
testing_set <- testing(split)

training_set %>%
  select(class) %>%
  table()
```

```
## class
##  bad good
##  310  253
```

```
testing_set %>%
  select(class) %>%
  table()
```

```
## class
##  bad good
##  104   86
```

```
training_set %>%
  select(subcorpus, class) %>%
  table()
```

```
##              class
## subcorpus     bad good
##   CzCDC       157    0
##   FrBo         56  171
##   KUKY         64   82
##   LiFRLaw       3    0
##   OmbuFlyers   30    0
```

```
testing_set %>%
  select(subcorpus, class) %>%
  table()
```

```
##              class
## subcorpus     bad good
##   CzCDC        54    0
##   FrBo         22   58
##   KUKY         20   28
##   LiFRLaw       0    0
##   OmbuFlyers    8    0
```

Tune

```
tune_res <- tibble(
  columns = character(),
  kernel = character(),
  gamma = numeric(),
  cost = numeric(),
  error = numeric(),
  dispersion = numeric()
)

# for (coli in seq_along(colsets)) {
#   colsid <- colsids[coli]
#   columns <- colsets[[coli]]

#   message("tune linear on ", colsid)
#   tune_linear <- tune.svm(training_set[columns], training_set$class,
#     cost = 10^(-3:1),
#     kernel = "linear"
#   )
#   tune_res <- tune_res %>%
#     bind_rows(tune_linear$performances %>%
#       mutate(kernel = "linear", columns = colsid, gamma = 0))

#   message("tune radial on ", colsid)
#   tune_radial <- tune.svm(training_set[columns], training_set$class,
#     gamma = 10^(-3:3),
#     cost = c(0.01, 0.1, 1, 10, 100, 1000),
#     kernel = "radial"
#   )
#   tune_res <- tune_res %>%
#     bind_rows(tune_radial$performances %>%
#       mutate(kernel = "radial", columns = colsid))

#   message("tune polynomial3 on ", colsid)
#   tune_polynomial <- tune.svm(training_set[columns], training_set$class,
#     gamma = 10^(-3:0),
#     degree = 3,
#     cost = 10^(-3:1),
#     kernel = "polynomial"
#   )
#   tune_res <- tune_res %>%
#     bind_rows(tune_polynomial$performances %>%
#       mutate(kernel = "polynomial3", columns = colsid))


#   message("tune polynomial4 on ", colsid)
#   tune_polynomial <- tune.svm(training_set[columns], training_set$class,
#     gamma = 10^(-3:-1),
#     degree = 4,
#     cost = 10^(-3:1),
#     kernel = "polynomial"
#   )
#   tune_res <- tune_res %>%
#     bind_rows(tune_polynomial$performances %>%
#       mutate(kernel = "polynomial4", columns = colsid))


#   message("tune polynomial5 on ", colsid)
#   tune_polynomial <- tune.svm(training_set[columns], training_set$class,
#     gamma = 10^(-3:-1),
#     degree = 5,
#     cost = 10^(-3:0),
#     kernel = "polynomial"
#   )
#   tune_res <- tune_res %>%
#     bind_rows(tune_polynomial$performances %>%
#       mutate(kernel = "polynomial5", columns = colsid))


#   message("tune sigmoid on ", colsid)
#   tune_sigmoid <- tune.svm(training_set[columns], training_set$class,
#     gamma = 10^(-3:3),
#     cost = 10^(-3:3),
#     kernel = "sigmoid"
#   )
#   tune_res <- tune_res %>%
#     bind_rows(tune_sigmoid$performances %>%
#       mutate(kernel = "sigmoid", columns = colsid))
# }

# tune_res %>% write_csv("tune_results.csv")
tune_res <- read_csv("tune_results.csv")
```

```
## Rows: 286 Columns: 7
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (2): columns, kernel
## dbl (5): gamma, cost, error, dispersion, degree
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
tune_res %>%
  arrange(error, -dispersion)
```

```
## # A tibble: 286 x 7
##    columns kernel  gamma   cost error dispersion degree
##    <chr>   <chr>   <dbl>  <dbl> <dbl>      <dbl>  <dbl>
##  1 all     radial  0.001 100    0.206      0.0576     NA
##  2 all     radial  0.01    1    0.208      0.0440     NA
##  3 all     sigmoid 0.001  10    0.210      0.0530     NA
##  4 all     radial  0.001  10    0.216      0.0679     NA
##  5 all     sigmoid 0.001 100    0.222      0.0759     NA
##  6 all     sigmoid 0.01    1    0.222      0.0690     NA
##  7 all     linear  0       1    0.224      0.0712     NA
##  8 all     radial  0.001   1    0.226      0.0458     NA
##  9 all     linear  0       0.1  0.226      0.0652     NA
## 10 all     linear  0       0.01 0.226      0.0662     NA
## # i 276 more rows
```

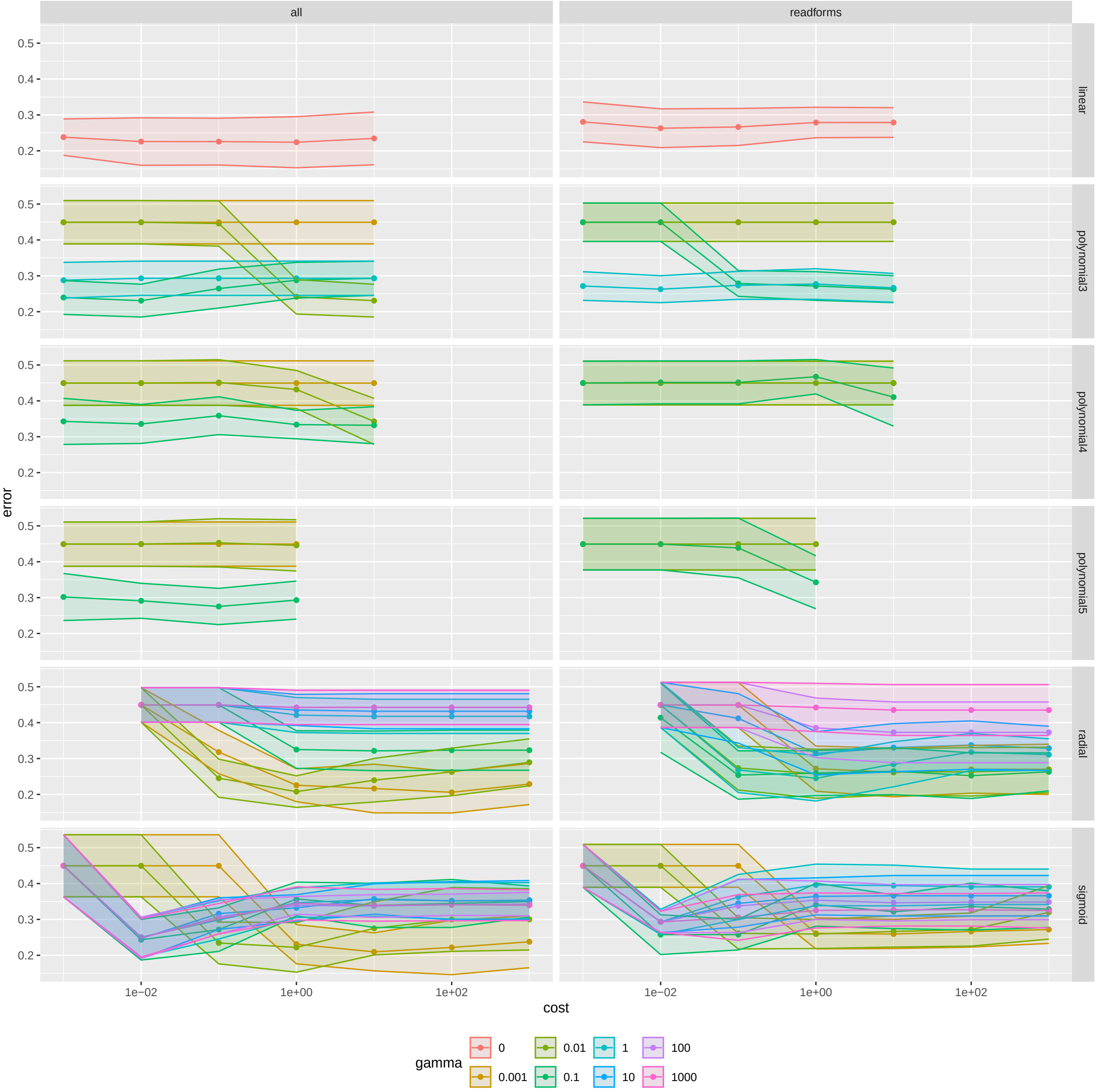
```
tune_res %>%
  filter(columns == "all") %>%
  arrange(error, -dispersion)
```

```
## # A tibble: 143 x 7
##    columns kernel  gamma   cost error dispersion degree
##    <chr>   <chr>   <dbl>  <dbl> <dbl>      <dbl>  <dbl>
##  1 all     radial  0.001 100    0.206      0.0576     NA
##  2 all     radial  0.01    1    0.208      0.0440     NA
##  3 all     sigmoid 0.001  10    0.210      0.0530     NA
##  4 all     radial  0.001  10    0.216      0.0679     NA
##  5 all     sigmoid 0.001 100    0.222      0.0759     NA
##  6 all     sigmoid 0.01    1    0.222      0.0690     NA
##  7 all     linear  0       1    0.224      0.0712     NA
##  8 all     radial  0.001   1    0.226      0.0458     NA
##  9 all     linear  0       0.1  0.226      0.0652     NA
## 10 all     linear  0       0.01 0.226      0.0662     NA
## # i 133 more rows
```

```
tune_res %>%
  filter(str_detect(columns, "notcorrelating.*")) %>%
  arrange(error, -dispersion)
```

```
## # A tibble: 0 x 7
## # i 7 variables: columns <chr>, kernel <chr>, gamma <dbl>, cost <dbl>,
## #   error <dbl>, dispersion <dbl>, degree <dbl>
```

```
tune_res %>%
  mutate(across(gamma, as.factor)) %>%
  ggplot(aes(
    x = cost, y = error, ymin = error - dispersion,
    ymax = error + dispersion, color = gamma, fill = gamma
  )) +
  geom_point() +
  geom_line() +
  geom_ribbon(alpha = 0.1) +
  scale_x_log10() +
  facet_grid(kernel ~ columns) +
  theme(legend.position = "bottom")
```



best:

- columns: all
- kernel: radial
- gamma: 0.01
- cost: 1

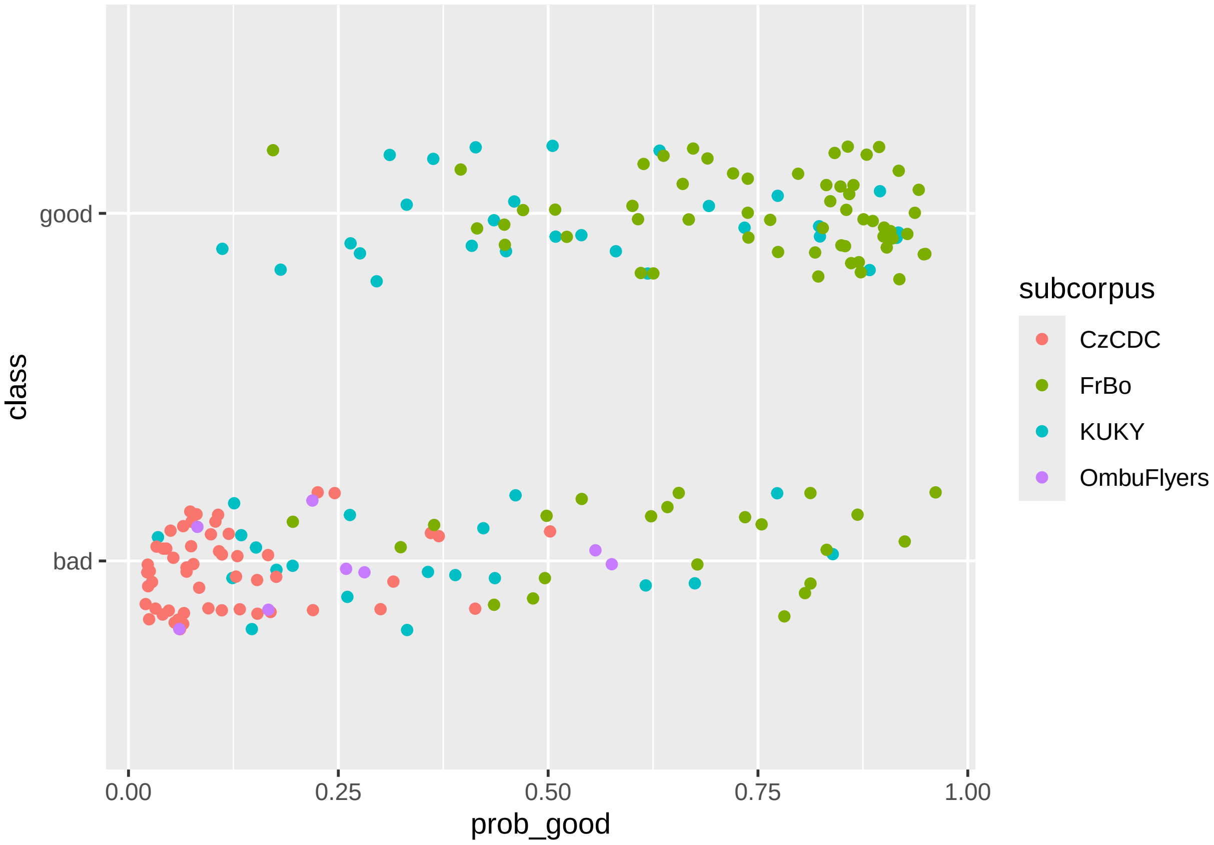
SVM

```
set.seed(42)

model_all <- train_svm(
  training_set, testing_set, columns_all, "radial",
  gamma = 0.01, cost = 1
)
model_all$cm
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction bad good
##       bad   82   19
##       good  22   67
##
##                Accuracy : 0.7842
##                  95% CI : (0.7189, 0.8405)
##     No Information Rate : 0.5474
##     P-Value [Acc > NIR] : 8.731e-12
##
##                   Kappa : 0.5658
##
##  Mcnemar's Test P-Value : 0.7548
##
##             Sensitivity : 0.7885
##             Specificity : 0.7791
##          Pos Pred Value : 0.8119
##          Neg Pred Value : 0.7528
##               Precision : 0.8119
##                  Recall : 0.7885
##                      F1 : 0.8000
##              Prevalence : 0.5474
##          Detection Rate : 0.4316
##    Detection Prevalence : 0.5316
##       Balanced Accuracy : 0.7838
##
##        'Positive' Class : bad
##
```

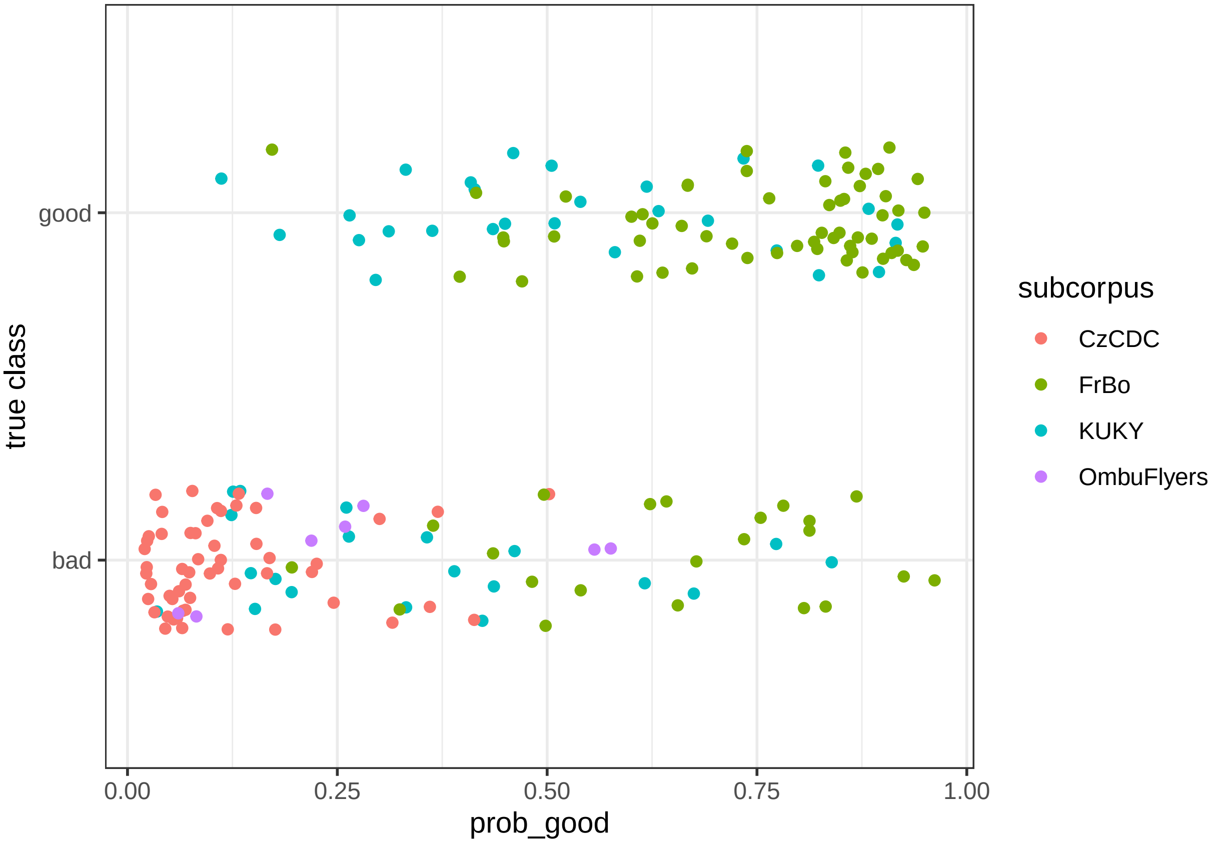
```
mismatches_all <- get_mismatch_details(model_all$prediction_set)
```



```
## Confusion matrices by subcorpora:
## , , subcorpus = CzCDC
##
##       class
## pred   bad good
##   bad   53    0
##   good   1    0
##
## , , subcorpus = FrBo
##
##       class
## pred   bad good
##   bad    7    6
##   good  15   52
##
## , , subcorpus = KUKY
##
##       class
## pred   bad good
##   bad   16   13
##   good   4   15
##
## , , subcorpus = LiFRLaw
##
##       class
## pred   bad good
##   bad    0    0
##   good   0    0
##
## , , subcorpus = OmbuFlyers
##
##       class
## pred   bad good
##   bad    6    0
##   good   2    0
##
##
## Greatest deviations:
## # A tibble: 41 x 5
##    abs_dev prob_good class subcorpus  FileName
##      <dbl>     <dbl> <fct> <fct>      <chr>
##  1   0.462     0.962 bad   FrBo       orig_Jaká pravidla platí pro veřejné zaká~
##  2   0.425     0.925 bad   FrBo       orig_Kompletní průvodce pořizováním nahrá~
##  3   0.388     0.112 good  KUKY       AK_JH_Hroch_ustavni_stiznost
##  4   0.369     0.869 bad   FrBo       orig_Jak řešit lavinovitou černou skládku~
##  5   0.339     0.839 bad   KUKY       PR_Konecny__Miliak
##  6   0.332     0.832 bad   FrBo       orig_Mohou spolky ve správních žalobách p~
##  7   0.328     0.172 good  FrBo       red_Certifikáty autorizovaných inspektorů
##  8   0.319     0.181 good  KUKY       Mestsky_urad_PRIKAZ
##  9   0.313     0.813 bad   FrBo       orig_Jaké trestné činy mohou souviset s k~
## 10   0.313     0.813 bad   FrBo       28
## 11   0.306     0.806 bad   FrBo       orig_Sousedské vztahy
## 12   0.281     0.781 bad   FrBo       orig_Jak se bránit neposkytnutí projektov~
## 13   0.273     0.773 bad   KUKY       PR_Masinova
## 14   0.254     0.754 bad   FrBo       orig_Jak se bránit obtěžování kouřem a pá~
## 15   0.235     0.265 good  KUKY       Mestsky_urad_usneseni_-_slouceni_pred
## 16   0.235     0.735 bad   FrBo       153
## 17   0.224     0.276 good  KUKY       Odvolani_proti_rozhodnuti_o_nepovoleni_ka~
## 18   0.204     0.296 good  KUKY       AK_JH_Podani_US_podpis
## 19   0.189     0.311 good  KUKY       Mestsky_urad_PRIKAZ_REV2
## 20   0.178     0.678 bad   FrBo       176
## 21   0.175     0.675 bad   KUKY       043_Plisen-a-zavady-v-byte
## 22   0.169     0.331 good  KUKY       6417_2023_VOP
## 23   0.156     0.656 bad   FrBo       orig_Kompletní průvodce občana obtěžované~
## 24   0.142     0.642 bad   FrBo       orig_Jak využít svého práva být informová~
## 25   0.137     0.363 good  KUKY       Mestsky_urad_kontrola_po
## 26   0.123     0.623 bad   FrBo       42
## 27   0.116     0.616 bad   KUKY       Dopis_studentské brigády
## 28   0.104     0.396 good  FrBo       red_Co je to úřední deska a jak ji využít
## 29   0.091     0.409 good  KUKY       Obecni urad_rozhodnuti zadost dle 106pdf
## 30   0.086     0.414 good  KUKY       Mestsky_urad_kontrola_pred
## 31   0.085     0.415 good  FrBo       156
## 32   0.076     0.576 bad   OmbuFlyers Pozemkove-urady
## 33   0.065     0.435 good  KUKY       Mestsky_urad__Vyzva_k_odstraneni_trabanta
## 34   0.056     0.556 bad   OmbuFlyers Skolstvi
## 35   0.052     0.448 good  FrBo       red_10 významných práv účastníka správníh~
## 36   0.052     0.448 good  FrBo       red_provokace_korupcniho_jednani
## 37   0.05      0.45  good  KUKY       Mestsky_urad_Nesoucinnost-U_sroz
## 38   0.04      0.46  good  KUKY       6421_2023_VOP
## # i 3 more rows
## Names of highest-deviating documents:
```

```
##  [1] "orig_Jaká pravidla platí pro veřejné zakázky malého rozsahu_final"
##  [2] "orig_Kompletní průvodce pořizováním nahrávek veřejné správy"
##  [3] "AK_JH_Hroch_ustavni_stiznost"
##  [4] "orig_Jak řešit lavinovitou černou skládku úprava svépomoc 2021"
##  [5] "PR_Konecny__Miliak"
##  [6] "orig_Mohou spolky ve správních žalobách používat věcné argumenty_final"
##  [7] "red_Certifikáty autorizovaných inspektorů"
##  [8] "Mestsky_urad_PRIKAZ"
##  [9] "orig_Jaké trestné činy mohou souviset s korupcí"
## [10] "28"
## [11] "orig_Sousedské vztahy"
## [12] "orig_Jak se bránit neposkytnutí projektové dokumentace"
## [13] "PR_Masinova"
## [14] "orig_Jak se bránit obtěžování kouřem a pálením odpadu"
## [15] "Mestsky_urad_usneseni_-_slouceni_pred"
## [16] "153"
## [17] "Odvolani_proti_rozhodnuti_o_nepovoleni_kaceni"
## [18] "AK_JH_Podani_US_podpis"
## [19] "Mestsky_urad_PRIKAZ_REV2"
## [20] "176"
## [21] "043_Plisen-a-zavady-v-byte"
```

```
mismatches_all$plot + theme_bw() + labs(y = "true class")
```



```
ggsave("model_all_probabilities.pdf")
```

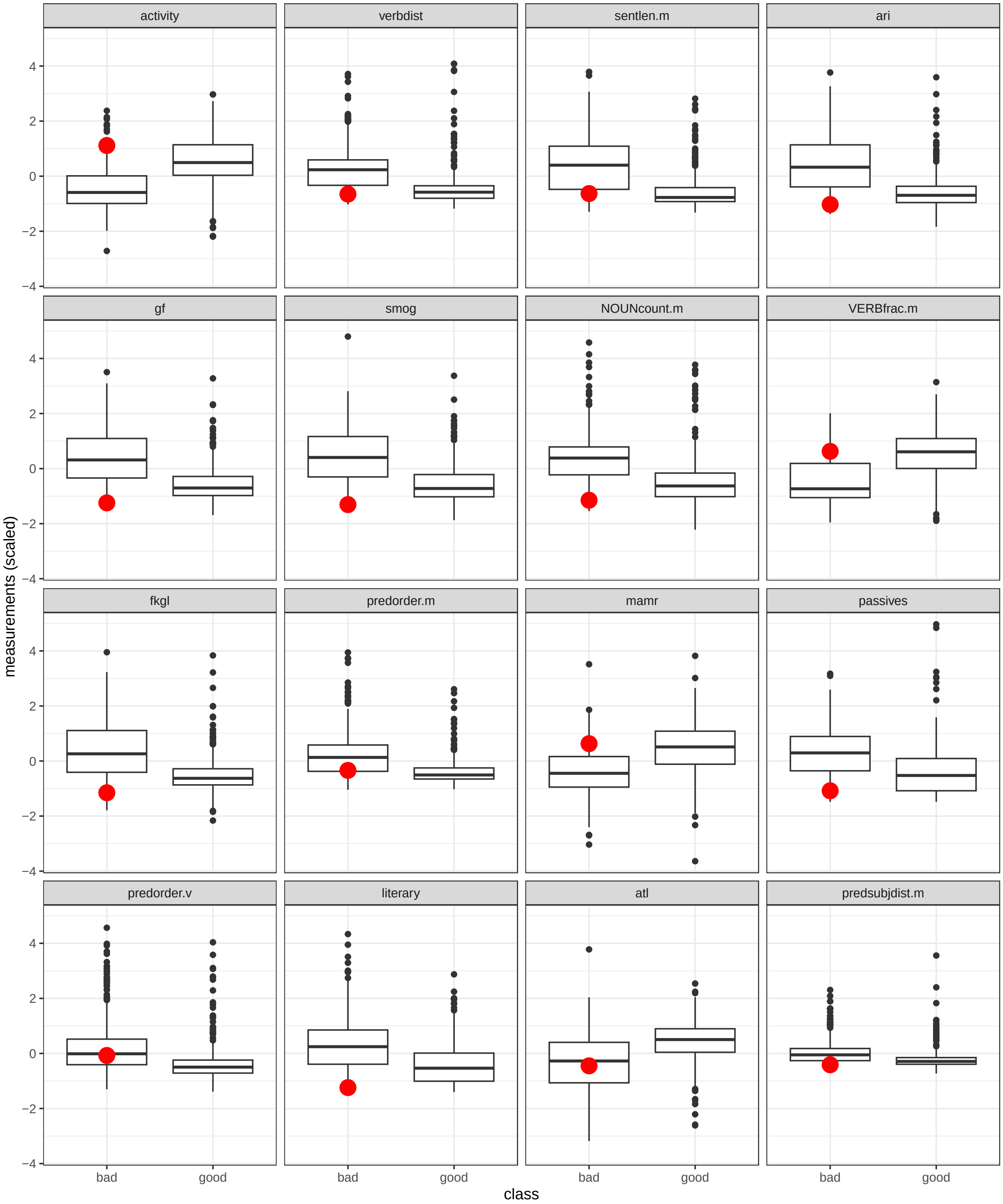
```
## Saving 6.5 x 4.5 in image
```

```r
for (doc in mismatches_all$highest_deviations) {
  doc_row <- mismatches_all$deviations %>% filter(FileName == doc)
  cat(paste(doc, "/", doc_row["subcorpus"][[1]], "\n"))
  cat("KUK_ID:", doc_row["KUK_ID"][[1]], "\n")
  cat("dev:", doc_row["abs_dev"][[1]] %>% round(3), "\n")

  plt <- plot_outlier(doc, variable_importances, data_clean) + theme_bw()
  print(plt)
  ggsave(paste(c("out_", doc_row["KUK_ID"][[1]], ".pdf"), collapse = ""), plt)
}
```

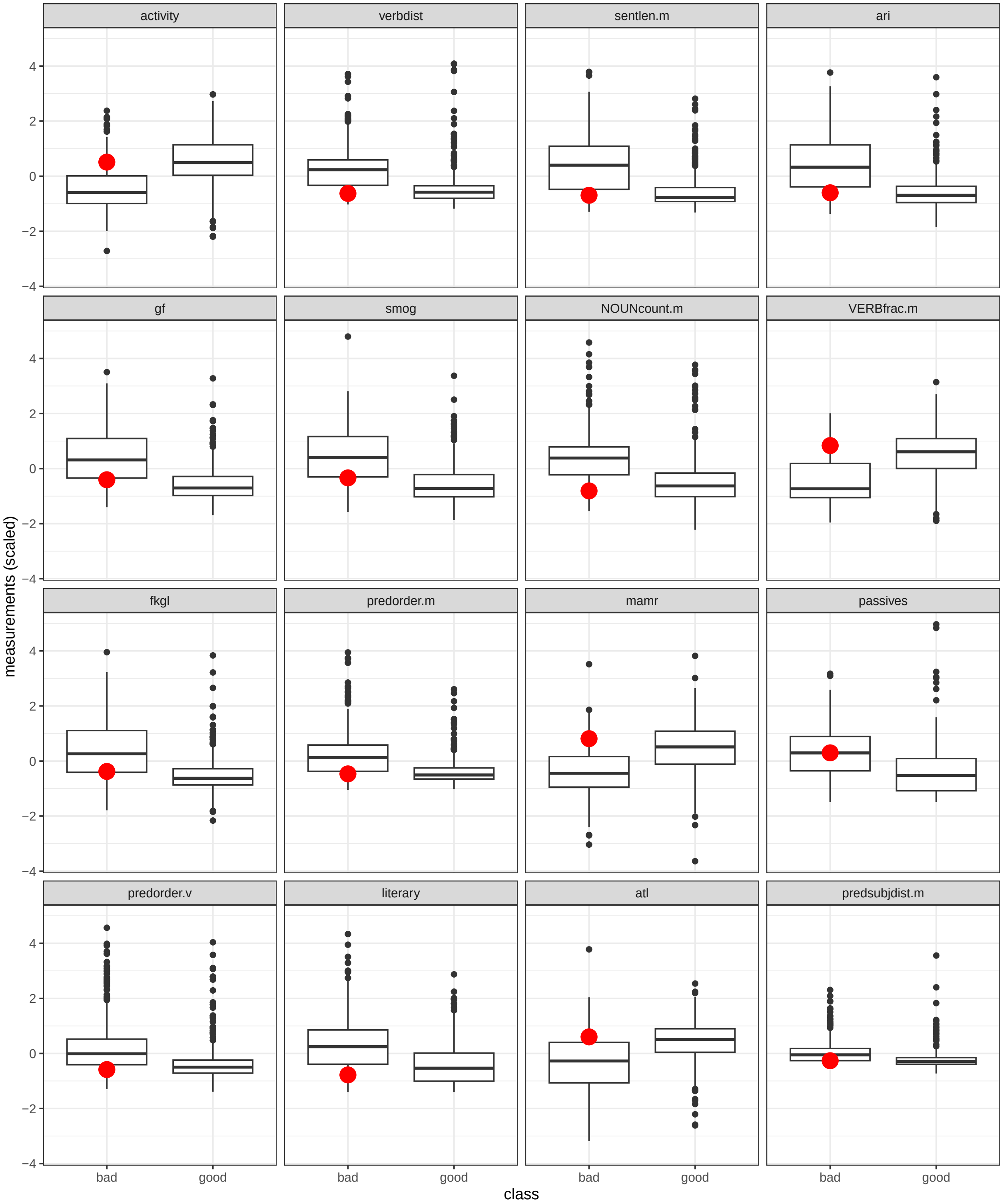
```
## orig_Jaká pravidla platí pro veřejné zakázky malého rozsahu_final / FrBo
## KUK_ID: Fart_orig_05482
## dev: 0.462
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



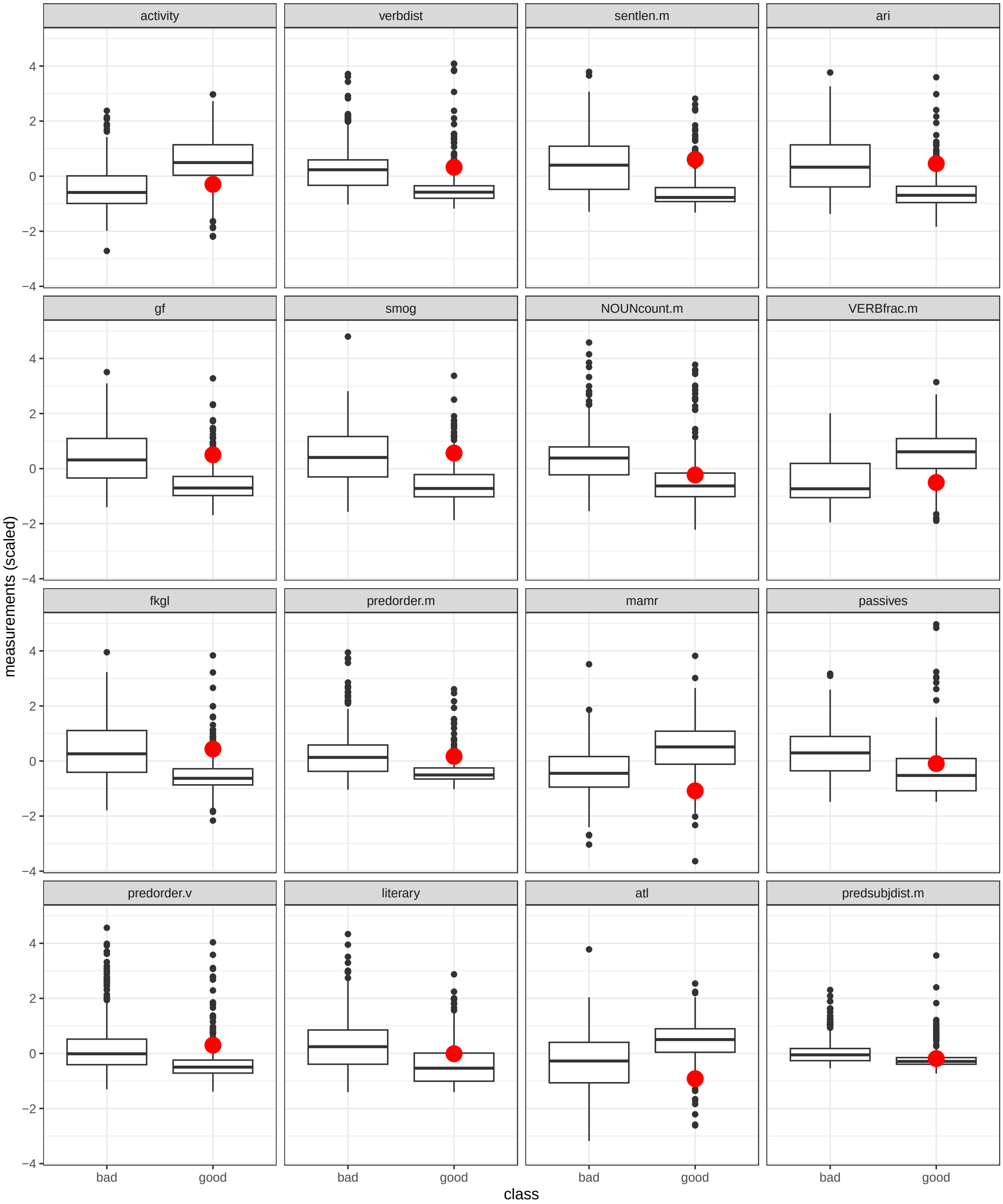
```
## orig_Kompletní průvodce pořizováním nahrávek veřejné správy / FrBo
## KUK_ID: Fart_orig_05648
## dev: 0.425
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



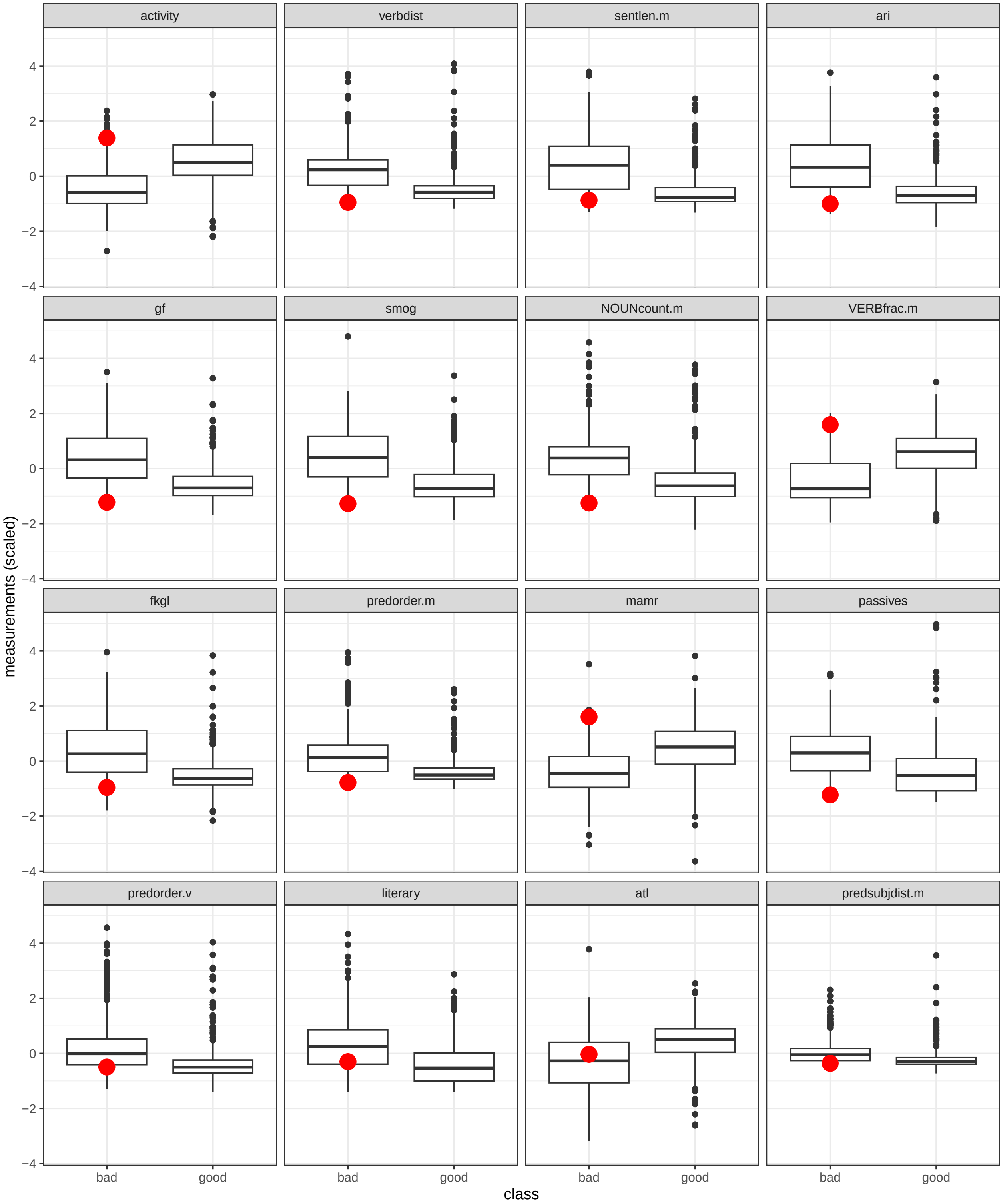
```
## AK_JH_Hroch_ustavni_stiznost / KUKY
## KUK_ID: 66f19554c6537d54ff062451
## dev: 0.388
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



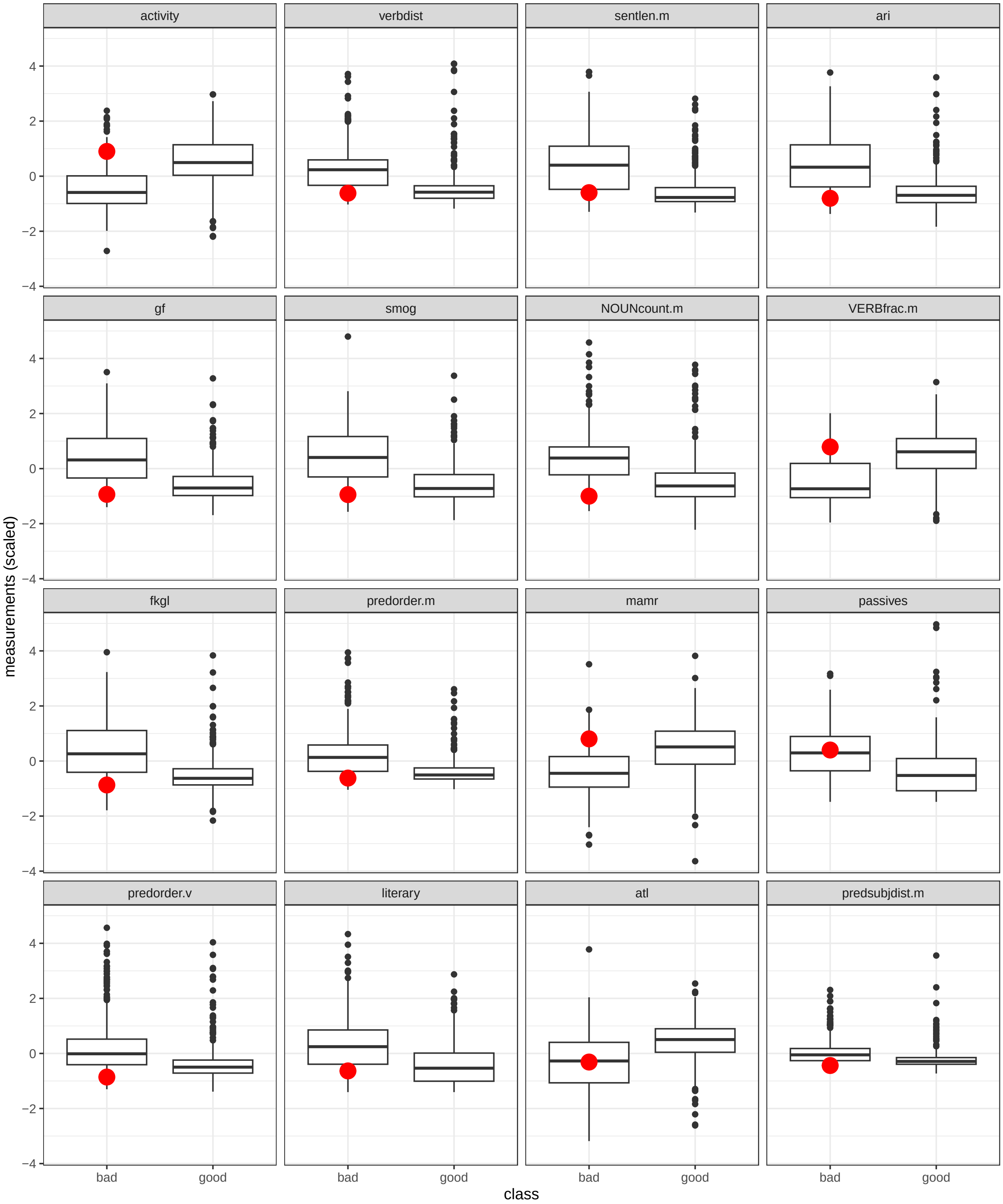
```
## orig_Jak řešit lavinovitou černou skládku úprava svépomoc 2021 / FrBo
## KUK_ID: Fart_orig_06078
## dev: 0.369
## 16 observation(s) removed from the plot

## Saving 10 x 12 in image
```



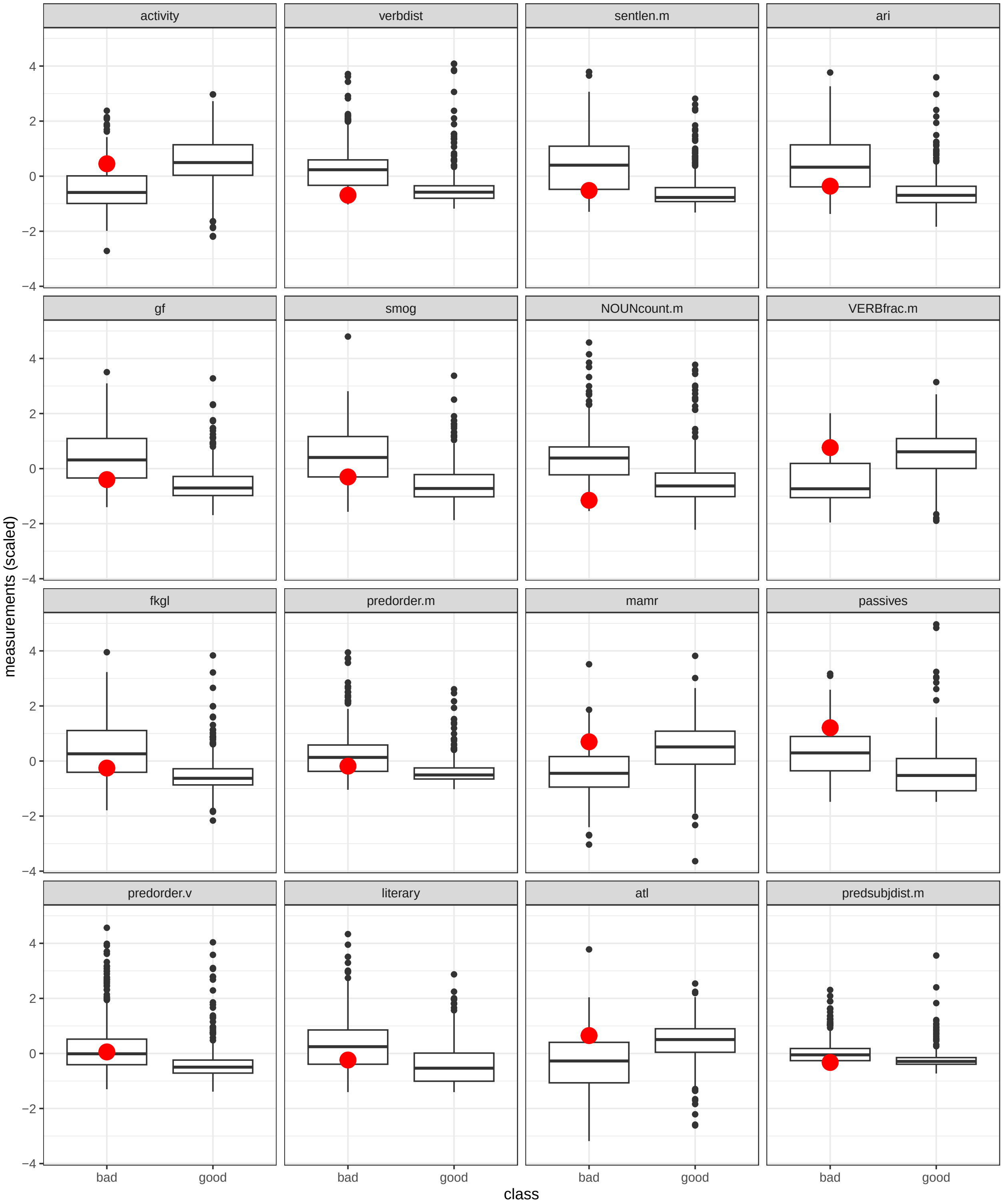
```
## PR_Konecny__Miliak / KUKY
## KUK_ID: 66f19554c6537d54ff062454
## dev: 0.339
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



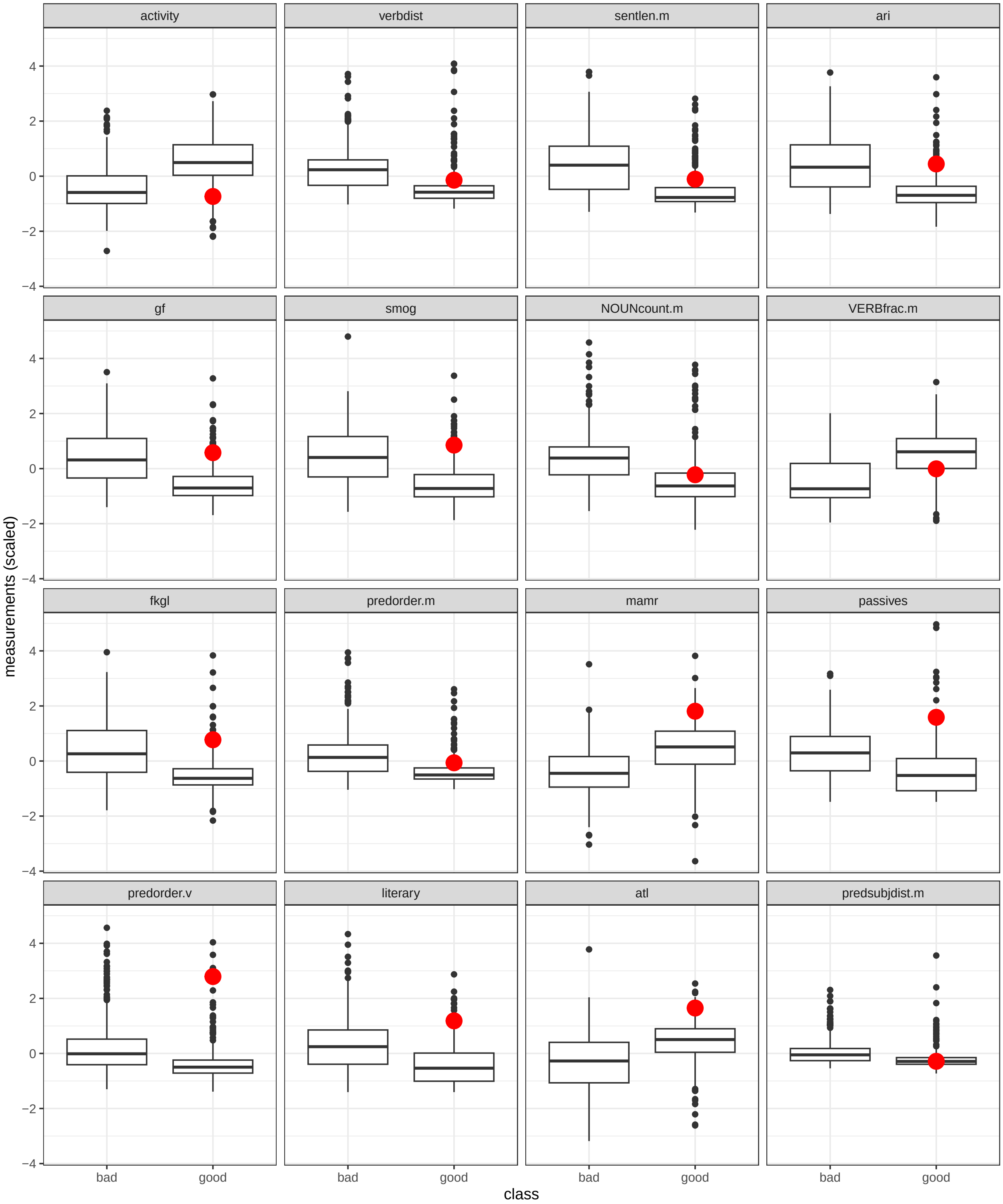
```
## orig_Mohou spolky ve správních žalobách používat věcné argumenty_final / FrBo
## KUK_ID: Fart_orig_5938b
## dev: 0.332
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



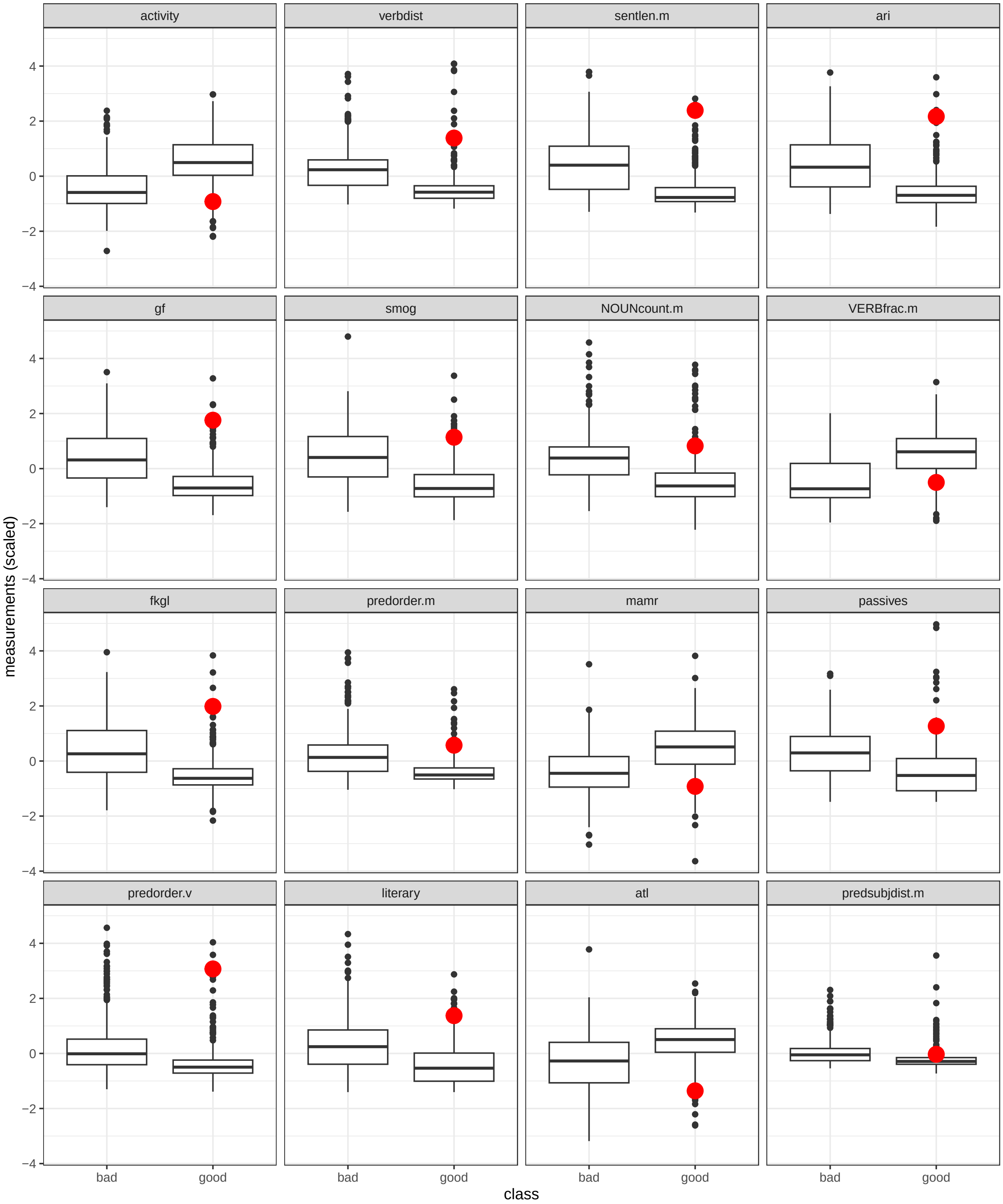
```
## red_Certifikáty autorizovaných inspektorů / FrBo
## KUK_ID: Fart_red_00253
## dev: 0.328
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



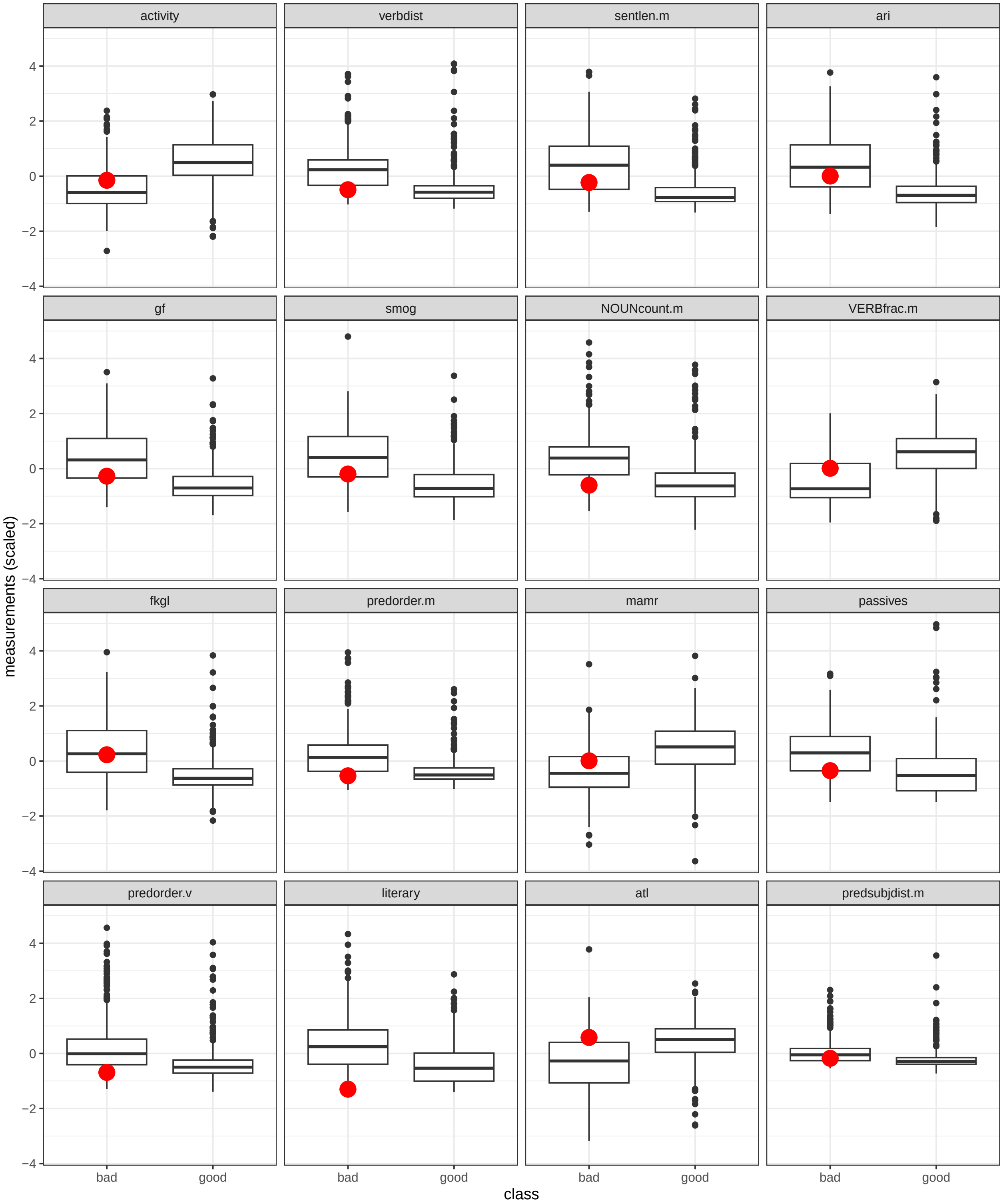
```
## Mestsky_urad_PRIKAZ / KUKY
## KUK_ID: 66f1be84c6537d54ff062490
## dev: 0.319
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



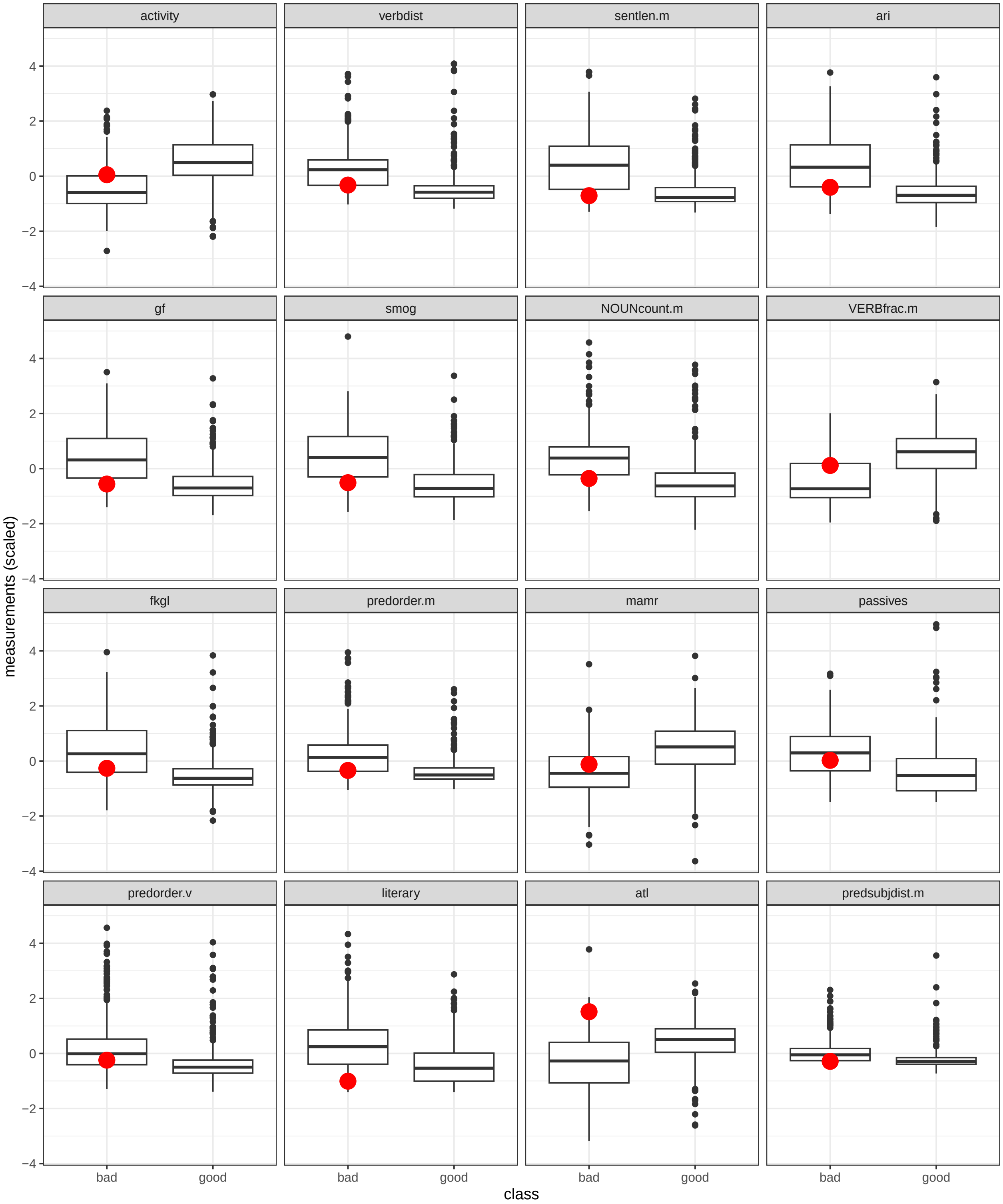
```
## orig_Jaké trestné činy mohou souviset s korupcí / FrBo
## KUK_ID: Fart_orig_00285
## dev: 0.313
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



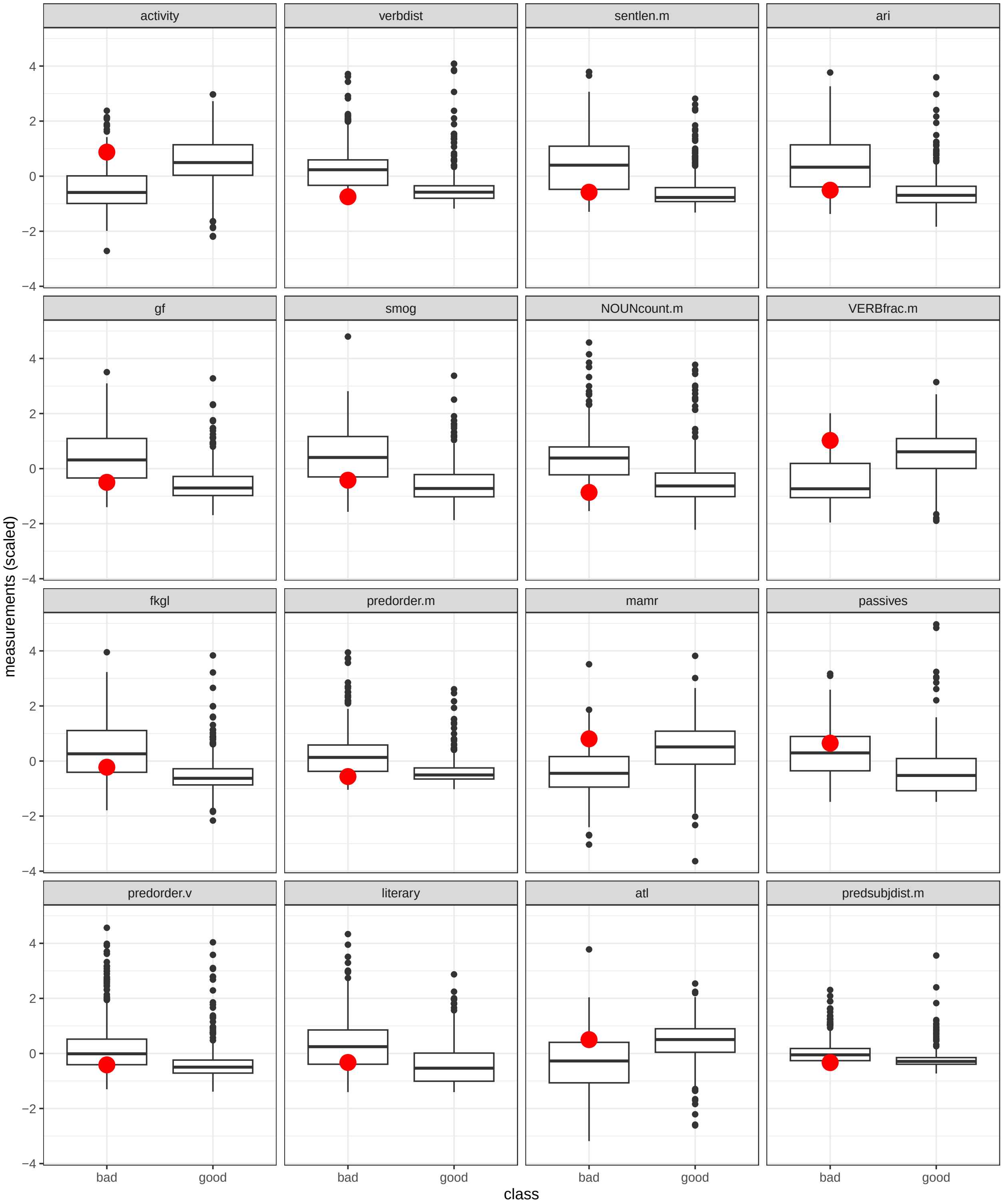
```
## 28 / FrBo
## KUK_ID: Fana_00028
## dev: 0.313
## 16 observation(s) removed from the plot

## Saving 10 x 12 in image
```



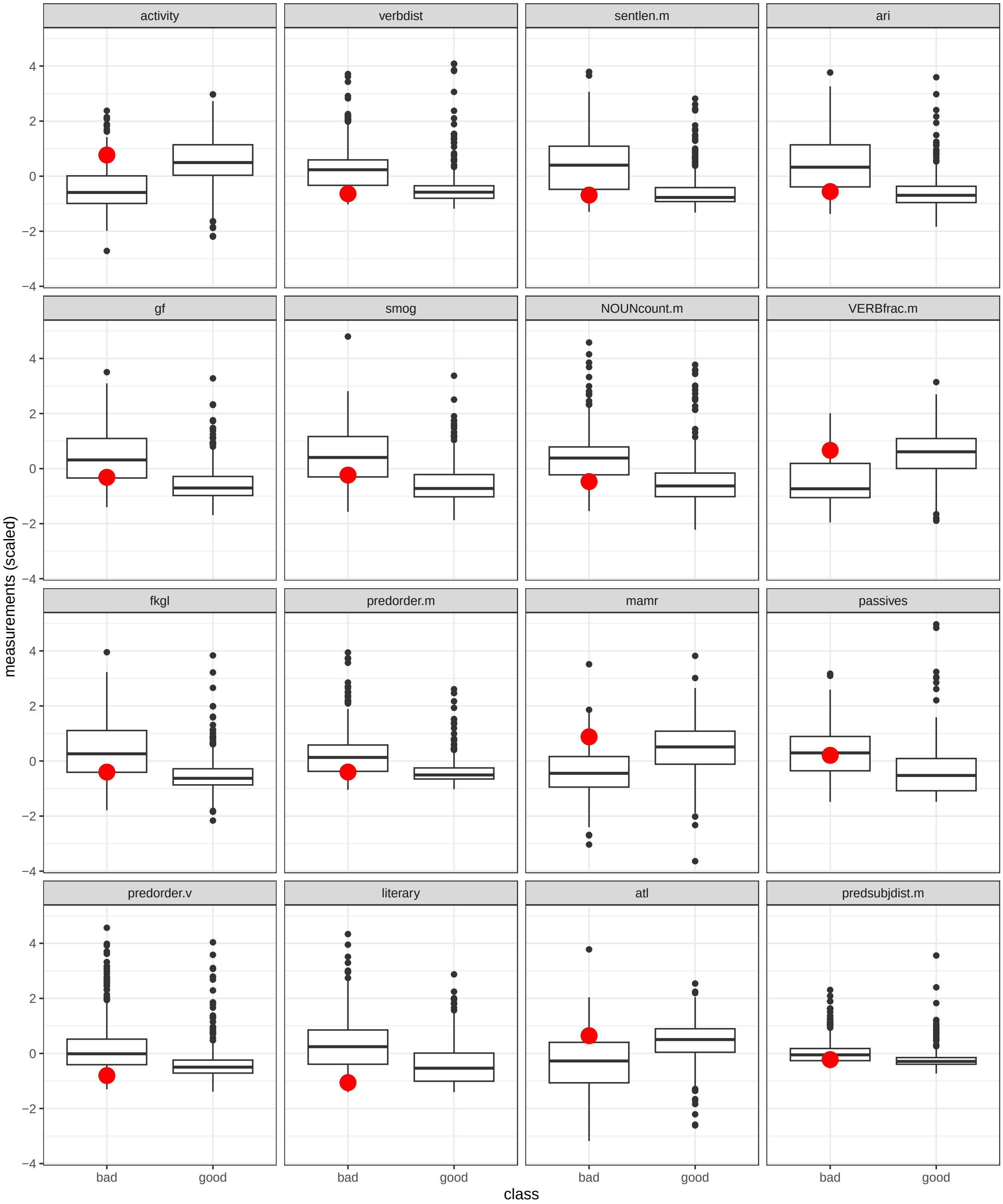
```
## orig_Sousedské vztahy / FrBo
## KUK_ID: Fart_orig_OmVfN
## dev: 0.306
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



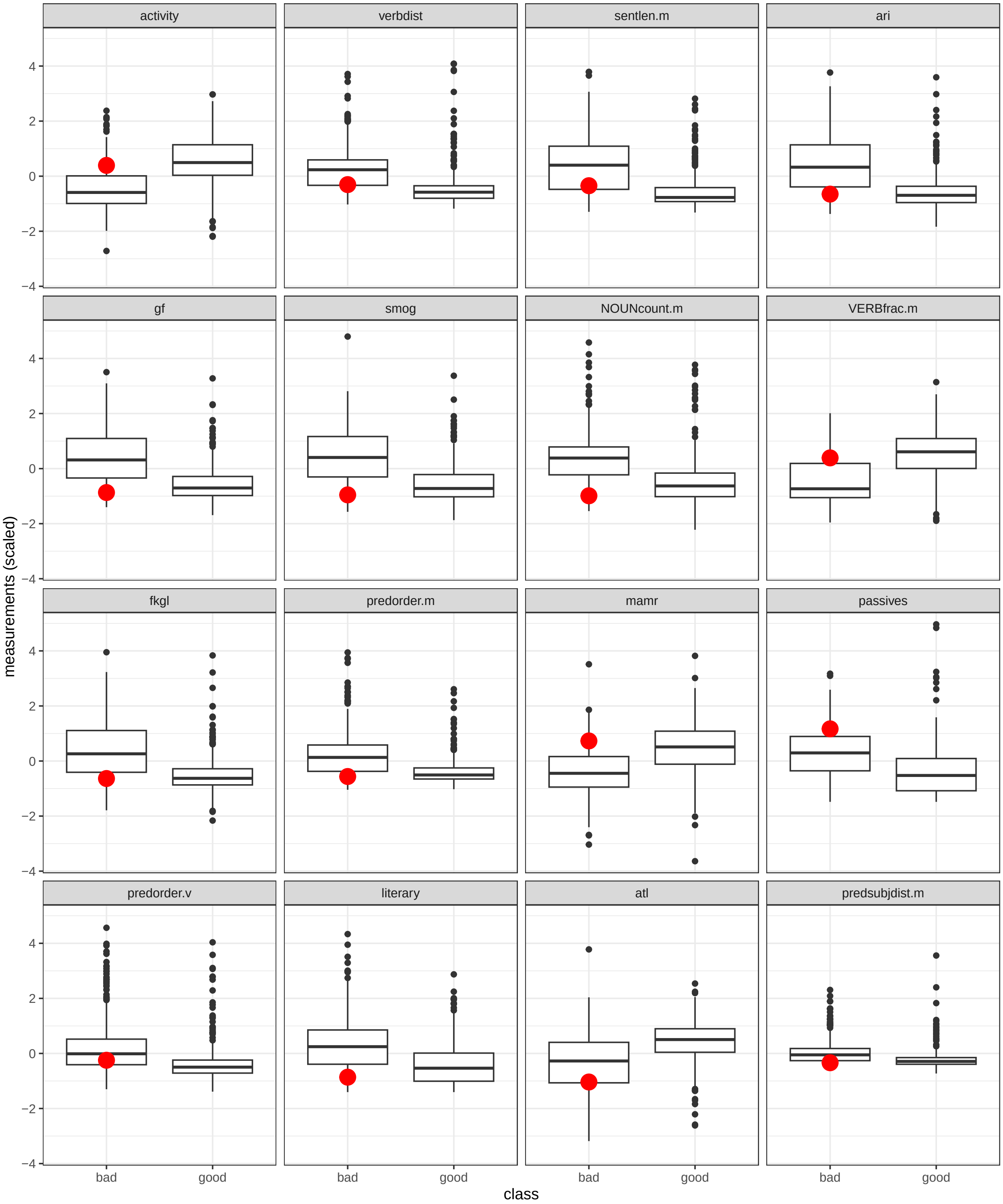
```
## orig_Jak se bránit neposkytnutí projektové dokumentace / FrBo
## KUK_ID: Fart_orig_00259
## dev: 0.281
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



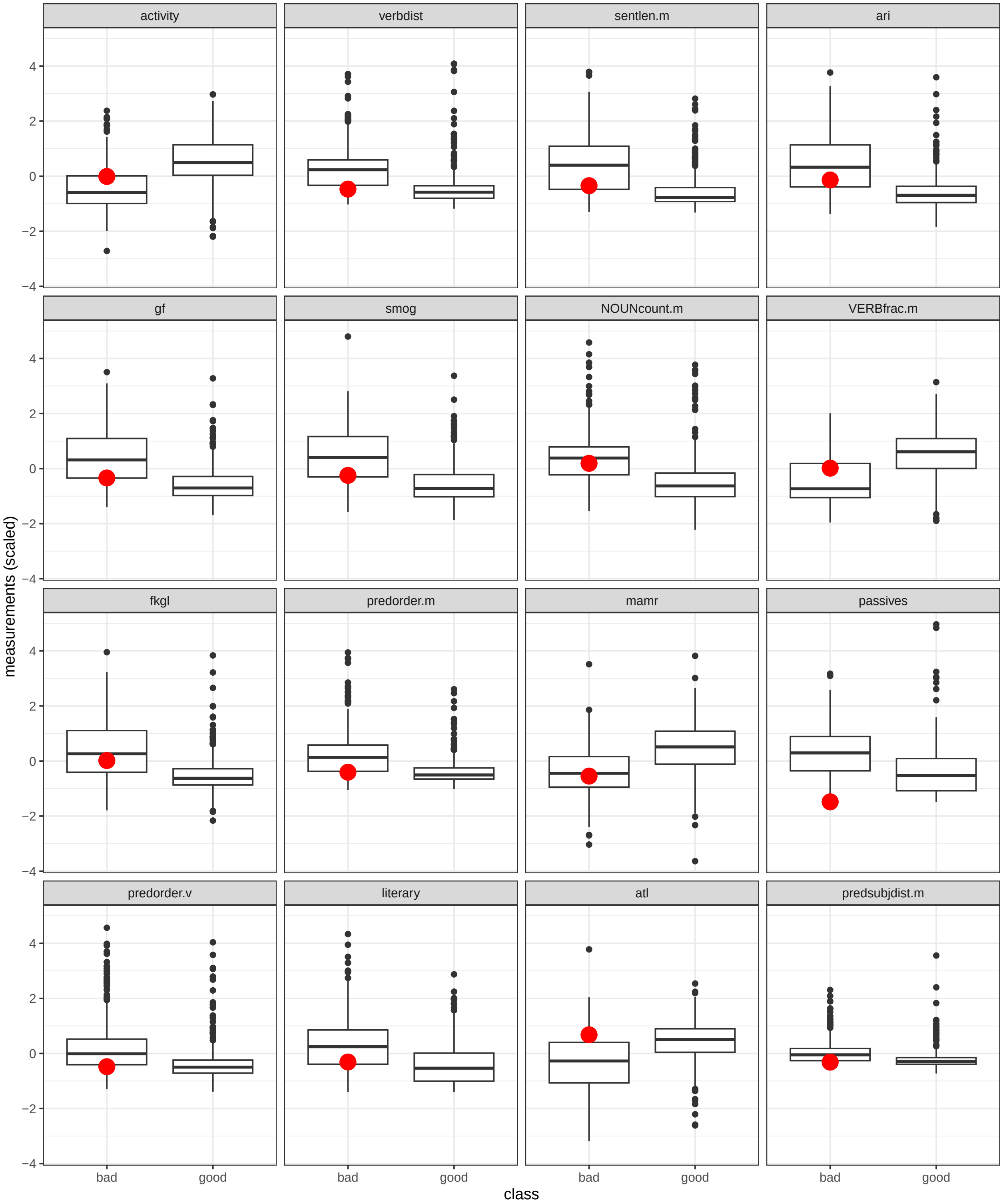
```
## PR_Masinova / KUKY
## KUK_ID: 66f19554c6537d54ff06244c
## dev: 0.273
## 16 observation(s) removed from the plot

## Saving 10 x 12 in image
```



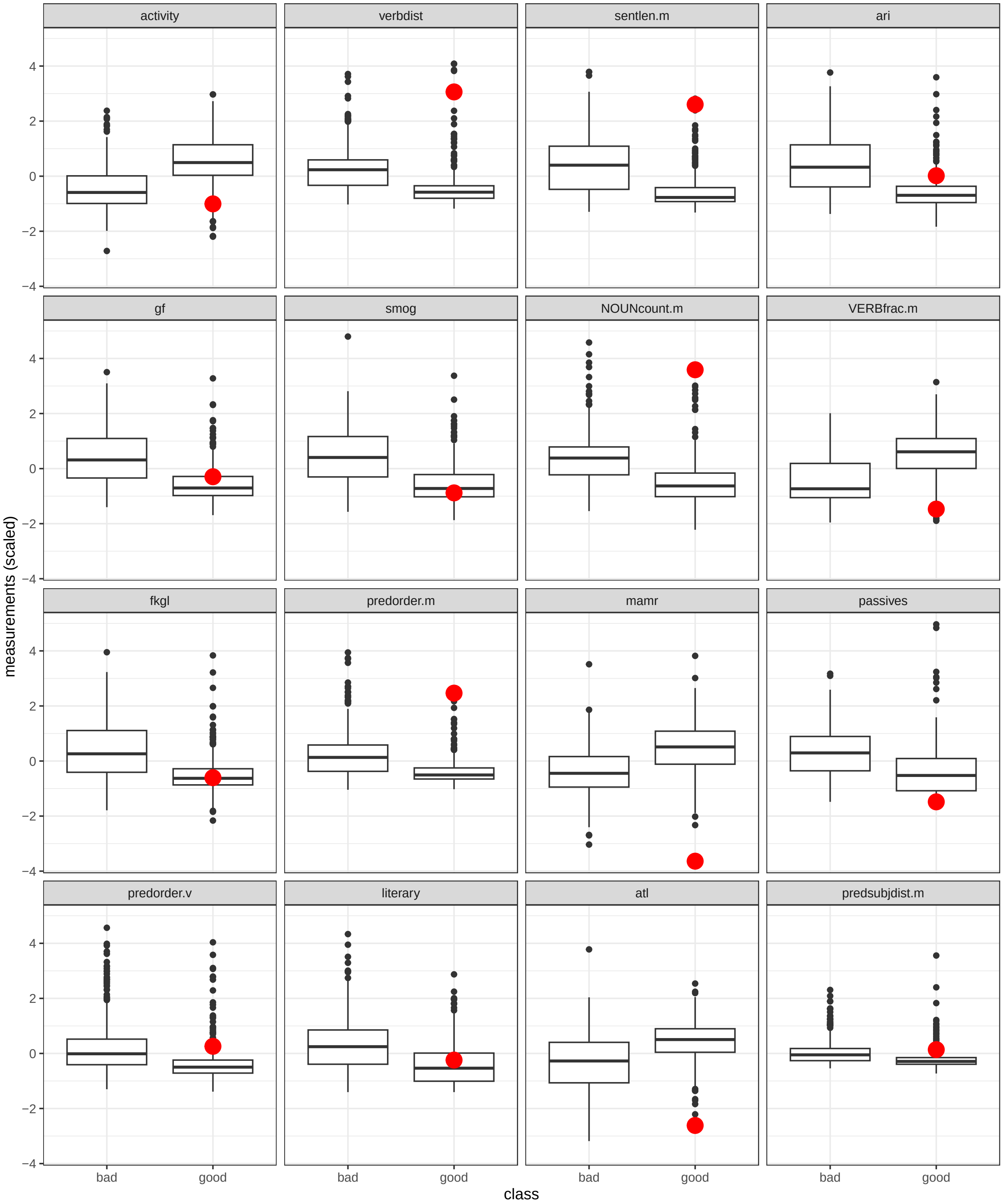
```
## orig_Jak se bránit obtěžování kouřem a pálením odpadu / FrBo
## KUK_ID: Fart_orig_05620
## dev: 0.254
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



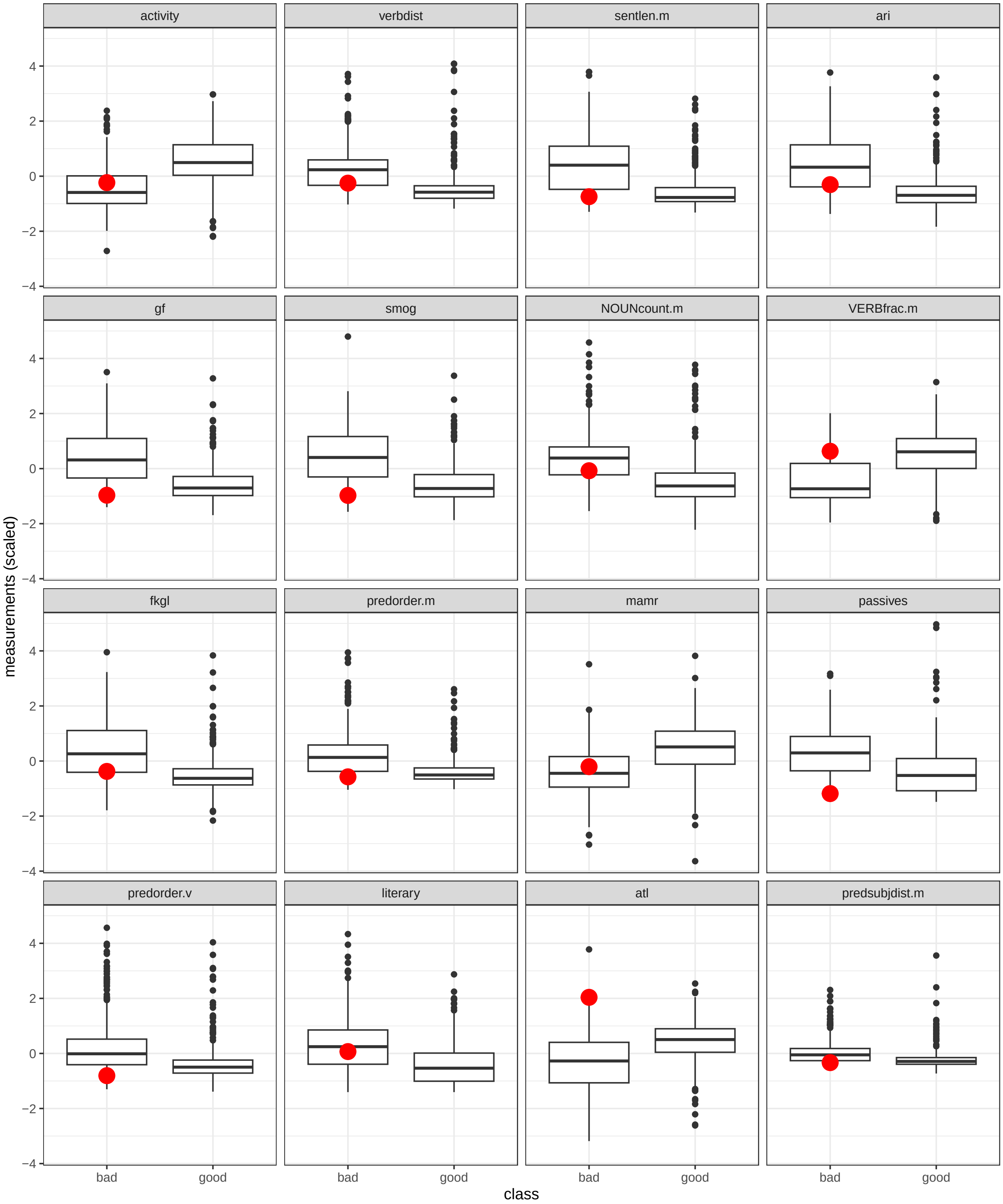
```
## Mestsky_urad_usneseni_-_slouceni_pred / KUKY
## KUK_ID: 66f19554c6537d54ff062453
## dev: 0.235
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



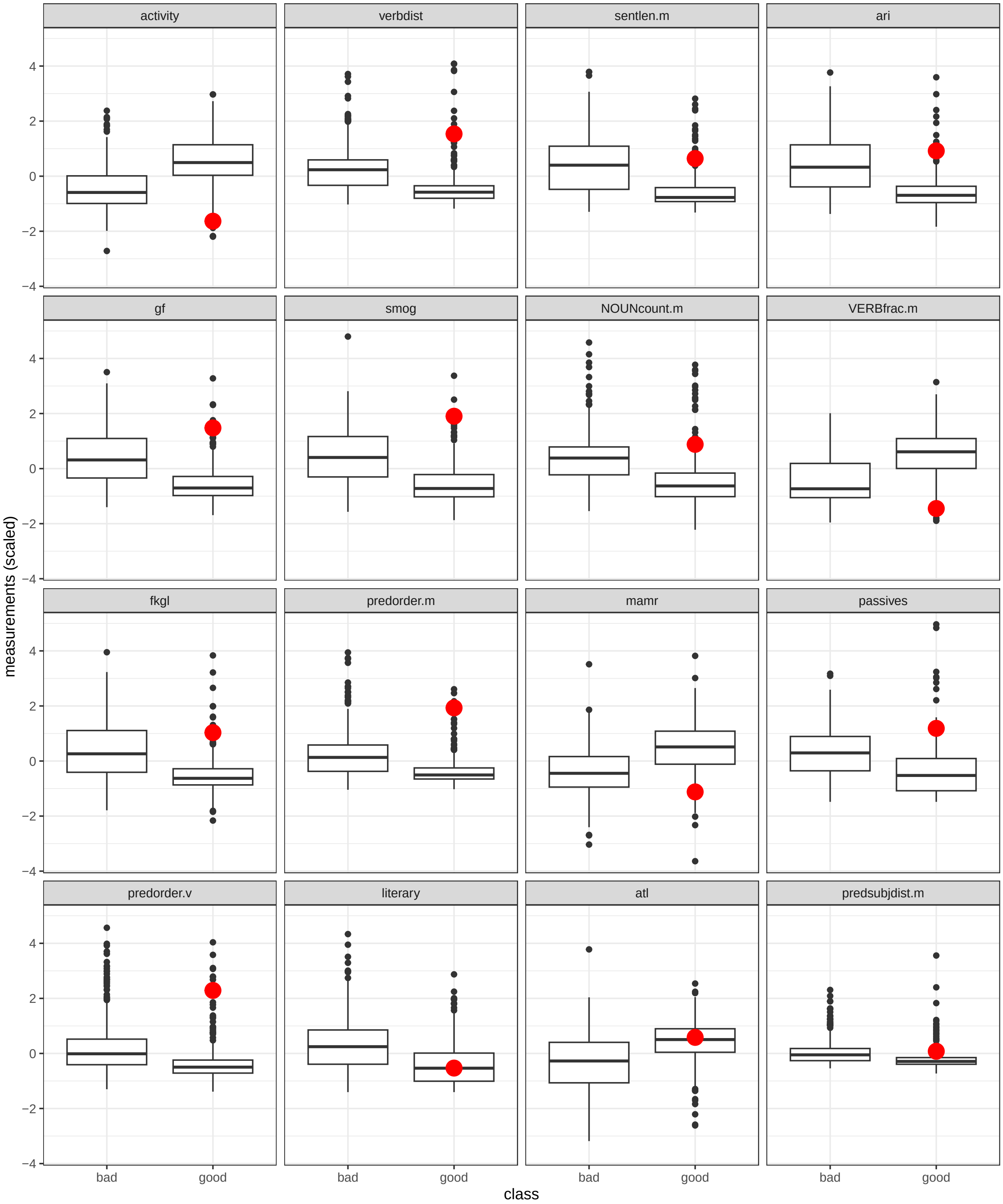
```
## 153 / FrBo
## KUK_ID: Fana_00153
## dev: 0.235
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



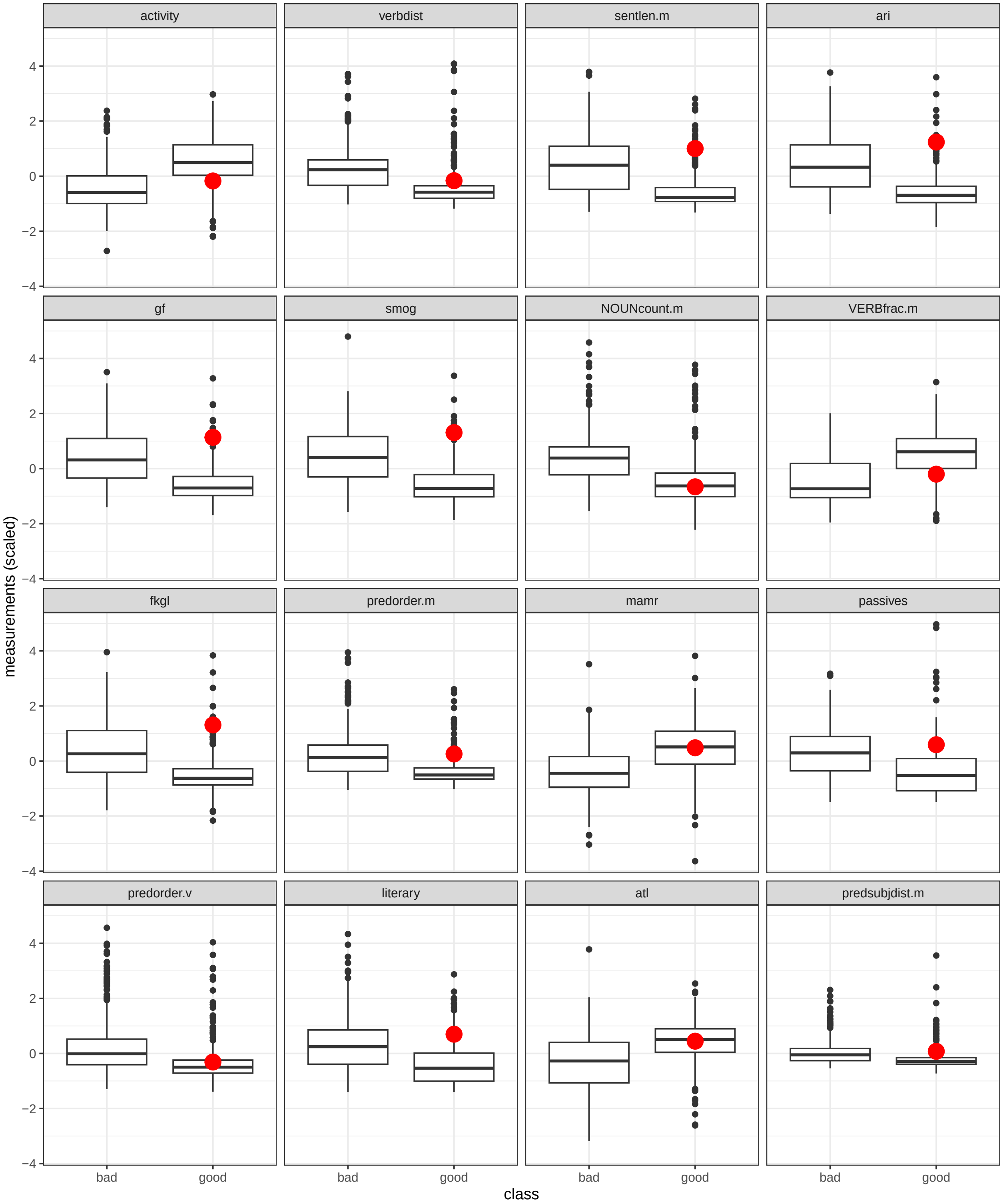
```
## Odvolani_proti_rozhodnuti_o_nepovoleni_kaceni / KUKY
## KUK_ID: 6745acb5c6537d54ff0636ca
## dev: 0.224
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



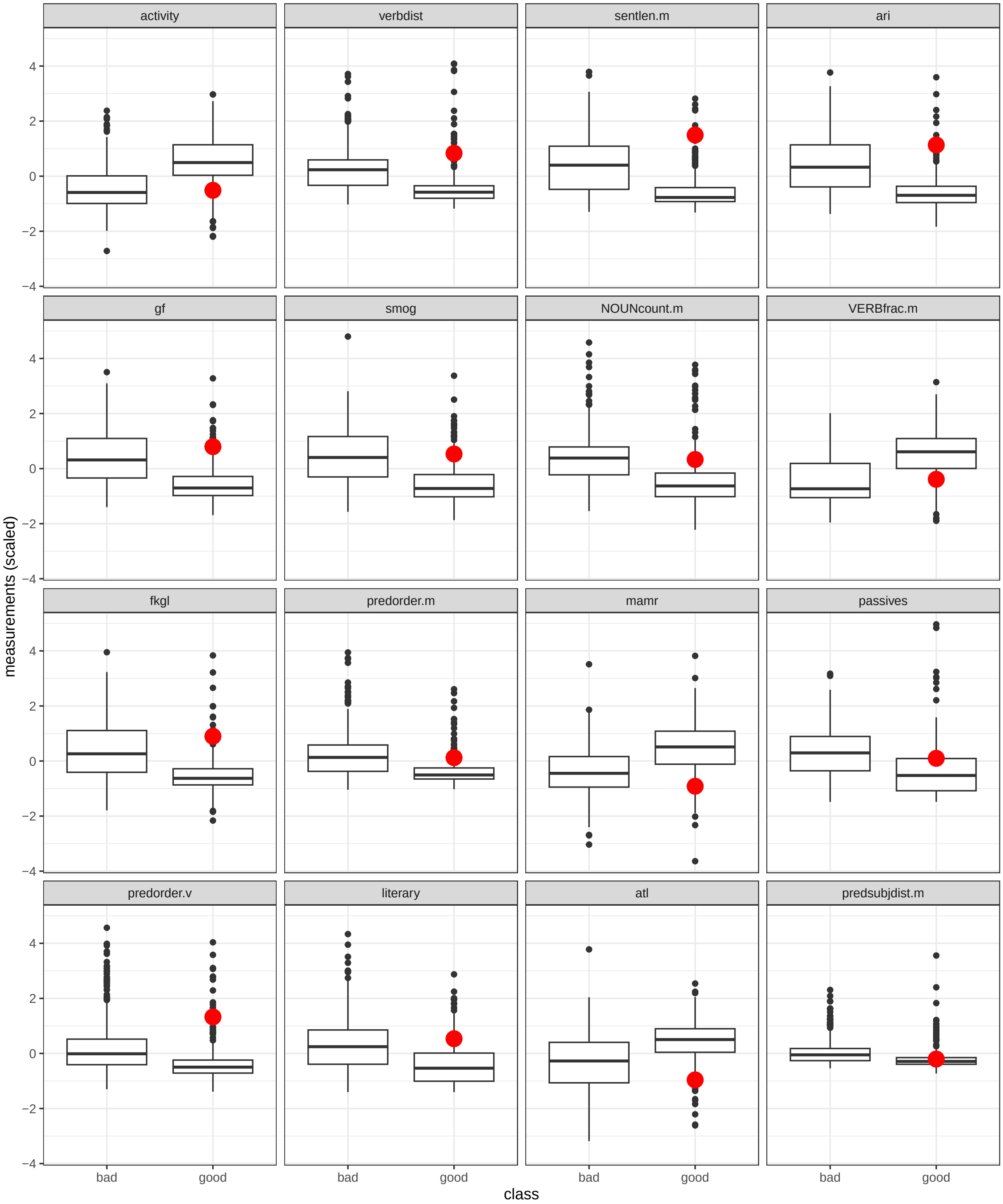
```
## AK_JH_Podani_US_podpis / KUKY
## KUK_ID: 66f19554c6537d54ff06244f
## dev: 0.204
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



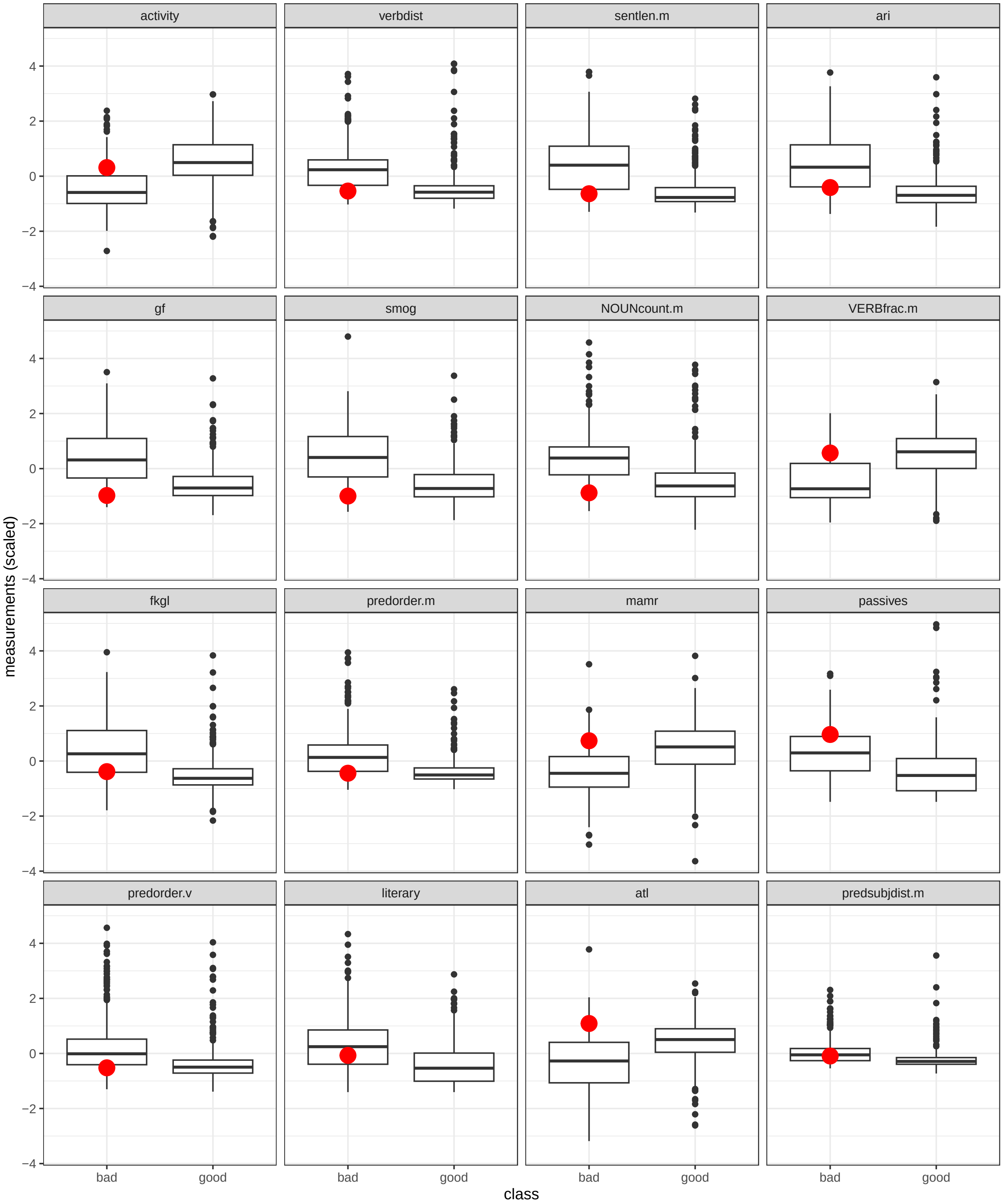
```
## Mestsky_urad_PRIKAZ_REV2 / KUKY
## KUK_ID: 66f1be84c6537d54ff062492
## dev: 0.189
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



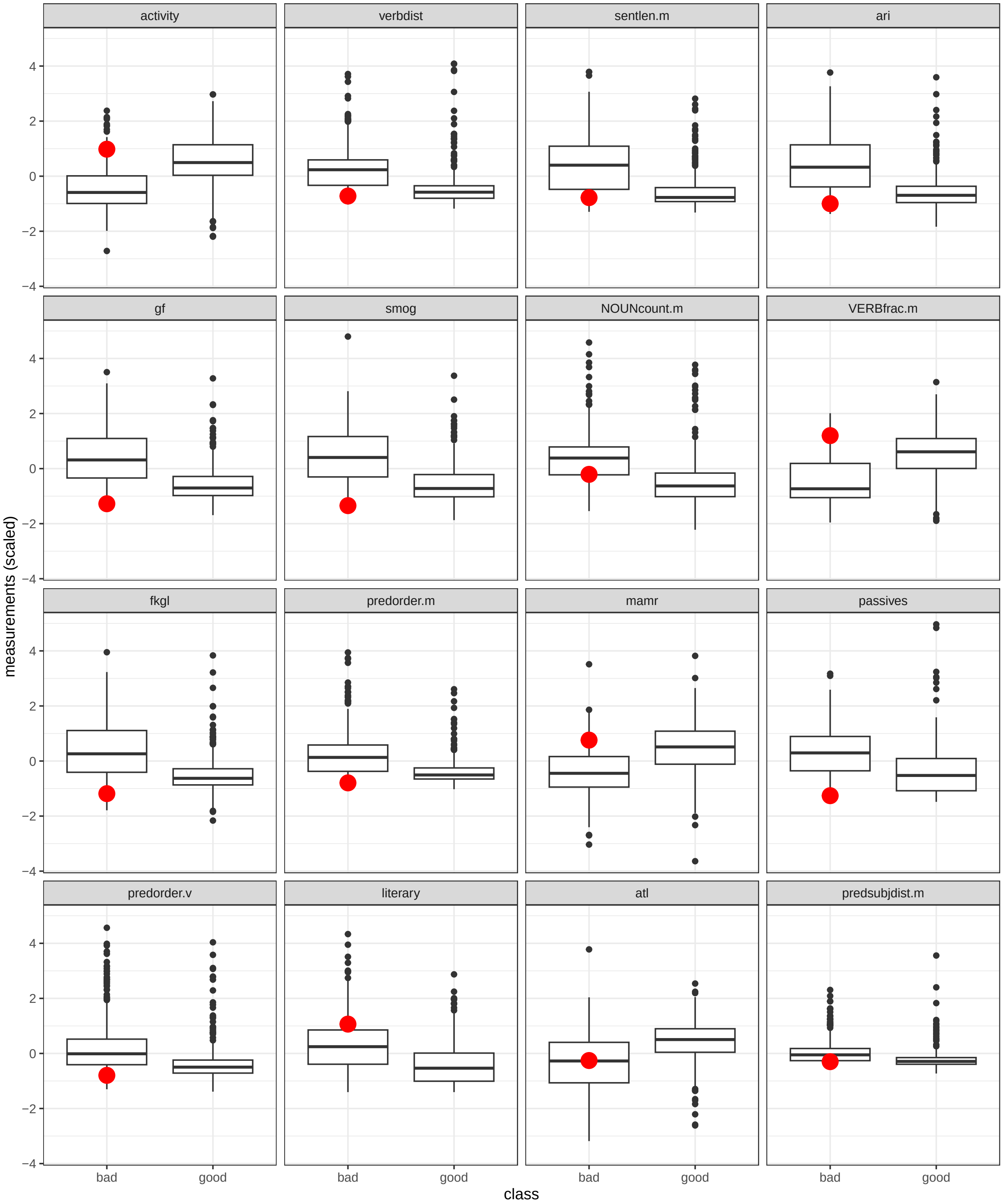
```
## 176 / FrBo
## KUK_ID: Fana_00176
## dev: 0.178
## 16 observation(s) removed from the plot

## Saving 10 x 12 in image
```



```
## 043_Plisen-a-zavady-v-byte / KUKY
## KUK_ID: 673b7a38c6537d54ff062bb3
## dev: 0.175
## 16 observation(s) removed from the plot
```

```
## Saving 10 x 12 in image
```



SVM readability formulas

```
model_rf <- train_svm(
  training_set, testing_set, columns_readabilty_forms, "radial",
  gamma = 0.01, cost = 1
)
model_rf$cm
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction bad good
##       bad   72   23
##       good  32   63
##
##                Accuracy : 0.7105
##                  95% CI : (0.6405, 0.7739)
##     No Information Rate : 0.5474
##     P-Value [Acc > NIR] : 2.942e-06
##
##                   Kappa : 0.4211
##
##  Mcnemar's Test P-Value : 0.2807
##
##             Sensitivity : 0.6923
##             Specificity : 0.7326
##          Pos Pred Value : 0.7579
##          Neg Pred Value : 0.6632
##               Precision : 0.7579
##                  Recall : 0.6923
##                      F1 : 0.7236
##              Prevalence : 0.5474
##          Detection Rate : 0.3789
##    Detection Prevalence : 0.5000
##       Balanced Accuracy : 0.7124
##
##        'Positive' Class : bad
##
```