

# Statistical Methods for Discrete Response, Time Series, and Panel Data (W271): Lab 2

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## Instructions:

- **Due Date: 10/23/2017**
- Submission:
  - Submit your own assignment via ISVC
  - Submit 2 files:
    1. A pdf file including the summary, the details of your analysis, and all the R codes used to produce the analysis. Please do not suppress the codes in your pdf file.
    2. R markdown file used to produce the pdf file
  - Each group only needs to submit one set of files
  - Use the following file naming convensation
    - \* SectionNumber\_hw01\_FirstNameLastNameFirstInitial.fileExtension
    - \* For example, if you are in Section 1 and have two students named John Smith and Jane Doe, you should name your file the following
      - Section1\_hw01\_JohnS\_JaneD.Rmd
      - Section1\_hw01\_JohnS\_JaneD.pdf
  - Although it sounds obvious, please write the name of each members of your group on page 1 of your report.
  - This lab can be completed in a group of up to 3 people. Each group only needs to make one submission. Although you can work by yourself, we encourage you to work in a group.
  - When working in a group, we encourage student not to use the “division-of-labor” approach to complete the lab. That is, do not divide the lab by having Student 1 completed questions 1 - 3, Student 2 completed questions 4 - 6, etc. Asking your teammates to do the questions for you is asking them take away your own opportunity to learn.
- Other general guidelines:
  - If you use R libraries and/or functions to conduct hypothesis tests not covered in this course, you will have to explain why the functions you use are appropriate for the hypothesis you are asked to test. Lacking explanations will result in a score of zero for the corresponding question.
  - Thoroughly analyze the given dataset. Detect any anomalies, including missing values, potential of top and/or bottom code, etc, in each of the variables.
  - Your report needs to include a comprehensive Exploratory Data Analysis (EDA) analysis, which includes both graphical and tabular analysis, as taught in this course. Output-dump (that is, graphs and tables that don’t come with explanations) will result in a very low, if not zero, score.

- Your analysis needs to be accompanied by detailed narrative. Remember, make sure your that when your audience (in this case, the professors and your classmates) can easily understand your your main conclusion and follow your the logic of your analysis. Note that just printing a bunch of graphs and model results, which we call “output dump”, will likely receive a very low score.
- Your rationale of any (EDA and modeling) decisions made in your modeling needs to be explained and supported with empirical evidence. Remember to use the insights generated from your EDA step to guide your modeling step, as we discussed in live sessions.
- All the steps to arrive at your final model need to be shown and explained very clearly.
- Students are expected to act with regards to UC Berkeley Academic Integrity.

## Description of the Business Problem, the Data, and Your Tasks

The file *lab2data.csv* summarizes a sample of the contributions received a private university. Information in each record in the sample includes graduating class (Class.Year), gender, marital status, major of studies when the alumnus attending the university (Major), whether or not the alumnus has attended any university events hosted by the Alumni organization between year 2012 and 2015 (AttendanceEvent), and the contribution in each of the years between 2012 and 2016 (FY12Giving, FY13Giving, etc). This is a carefully constructed sample, including only alumni who graduated from the institution and not the former students who spent time at the institution without graduating. Alumni not contributing have the entry “0” in the related column.

For a university foundation, it is very important to know who is contributing, because those information allows the foundation to target their fund-raising resources to those alumni who are likely to donate in the future.

In this lab, your group, as a team of data scientists working for the university foundation, are tasked to utilize the given information to predict who are likely to donate in the future. The data, *lab2data.csv*, contains recent historical information. You will need to build a model to predict the most recent (i.e. fiscal year 2016) contribution “category” using techniques covered in lecture 1 - 5.

The variable of interest is *FY16Giving*, which is a numeric variable. However, I’d like you to create another variable, named *FY16GivingCat*, representing various categories of contribution in 2016. The categories are [0, 1), [1, 100), [100, 250), [250, 500), [500, 200000). Note that we specifically want to separate out those who did not contribute and put them in the [0, 1) bin.

Even though I said “build a model”, you are more than likely to experiment various model specifications as well as techniques. Some may consider using multinomial logistic regression, even though the categories are clearly ordered.

As in any data science project, start your project with examination of the data and then exploratory analysis. These analyses will help the administration of the university foundation to understand the sample (before you present any model results to them). In fact, your report should consider the following sections:

- Section 1: An introduction to the project, which should include a concise summary of the key results as well as techniques you used in your final model.
- Section 2: Data examination and EDA. This section should statr with a summary of the key insights you learn from examining the data and conducting the EDA. Since there will be a page limit (see below), select your graphical and tabular results carefully and accompany each one with narrative. **DO NOT USE OUTPUT DUMP!**
- Section 3: Statistical Modeling. Start the section summarizing the key results - what variables, if any, are the key predictors of the year 2016 contribution? What are the key techniques you have experimented? What method did you use in your final model? How did you choose the final model? What model performance criteria did you use to choose the final model? What statistical infernece did you perform? Explain them. Comment on statistical significance vs. economic significance.

- Section 4: Final Remarks. After examining the data and using the data to build a predictive model, what are your departing thoughts? What are the strengths and weaknesses in your analysis? Should the administration trust your result? Are there subsample in your sample that your model did a bad job in predicting their contribution behavior? If so, why? Are there other “things”, a wish list, that you think can be used to improve your model? If so, what are they? Perhaps you can make a suggestion to the administration to collect those information in the future.

## Scratch area, just experiments

### Data Loading

```
# Load CSV
df <- read.csv("lab2data.csv", stringsAsFactors = TRUE, header = TRUE, sep = ",")

# Make factors
df$Years.Since.Graduation = 2017 - df$Class.Year
df$AttendanceEvent = factor(df$AttendanceEvent)
df$Major = factor(df$Major)
# Categorize FY16Giving
df$FY16GivingCat = cut(x = df$FY16Giving, c(0, 1, 100, 250, 500, 200000), right = FALSE)

str(df)

## 'data.frame':    1000 obs. of  14 variables:
##  $ X                : int  761 620 214 373 748 1080 1155 1069 1161 457 ...
##  $ Gender            : Factor w/ 2 levels "F","M": 1 2 1 1 2 1 1 1 1 1 ...
##  $ Class.Year        : int  2002 2002 1982 1992 2002 2012 2012 2012 2012 1992 ...
##  $ Marital.Status    : Factor w/ 4 levels "D","M","S","W": 2 3 2 2 3 3 3 3 3 2 ...
##  $ Major             : Factor w/ 45 levels "American Studies",...: 39 25 25 2 30 2 3 26 39 15 ...
##  $ Next.Degree       : Factor w/ 47 levels "AA","BA","BAE",...: 37 39 39 35 39 15 39 35 39 18 ...
##  $ AttendanceEvent   : Factor w/ 2 levels "0","1": 2 1 2 2 1 2 1 2 1 1 ...
##  $ FY12Giving        : num  50 0 100 0 0 0 0 5 0 0 ...
##  $ FY13Giving        : num  51 0 0 0 0 0 0 10 0 75 ...
##  $ FY14Giving        : num  51 0 100 0 0 0 0 25 0 0 ...
##  $ FY15Giving        : num  0 0 100 0 0 0 0 25 0 0 ...
##  $ FY16Giving        : num  0 0 100 0 0 0 0 50 0 60 ...
##  $ Years.Since.Graduation: num  15 15 35 25 15 5 5 5 5 25 ...
##  $ FY16GivingCat     : Factor w/ 5 levels "[0,1)","[1,100)",...: 1 1 3 1 1 1 1 2 1 2 ...

head(df)

##      X Gender Class.Year Marital.Status      Major Next.Degree
## 1  761      F      2002           M      Sociology      MSW
## 2  620      M      2002           S      History      NONE
## 3  214      F      1982           M      History      NONE
## 4  373      F      1992           M Anthropology      MS
## 5  748      M      2002           S  Philosophy      NONE
## 6 1080      F      2012           S Anthropology      JD
##  AttendanceEvent FY12Giving FY13Giving FY14Giving FY15Giving FY16Giving
## 1              1         50         51         51          0          0
## 2              0          0          0          0          0          0
## 3              1        100          0        100        100        100
## 4              1          0          0          0          0          0
## 5              0          0          0          0          0          0
## 6              1          0          0          0          0          0
##  Years.Since.Graduation FY16GivingCat
## 1              15      [0,1)
## 2              15      [0,1)
## 3              35    [100,250)
## 4              25      [0,1)
## 5              15      [0,1)
```

```
## 6          5          [0,1)
```

## Limits, outliers and missing values:

We'll use Hmisc package throughout this section.

```
library(Hmisc)
```

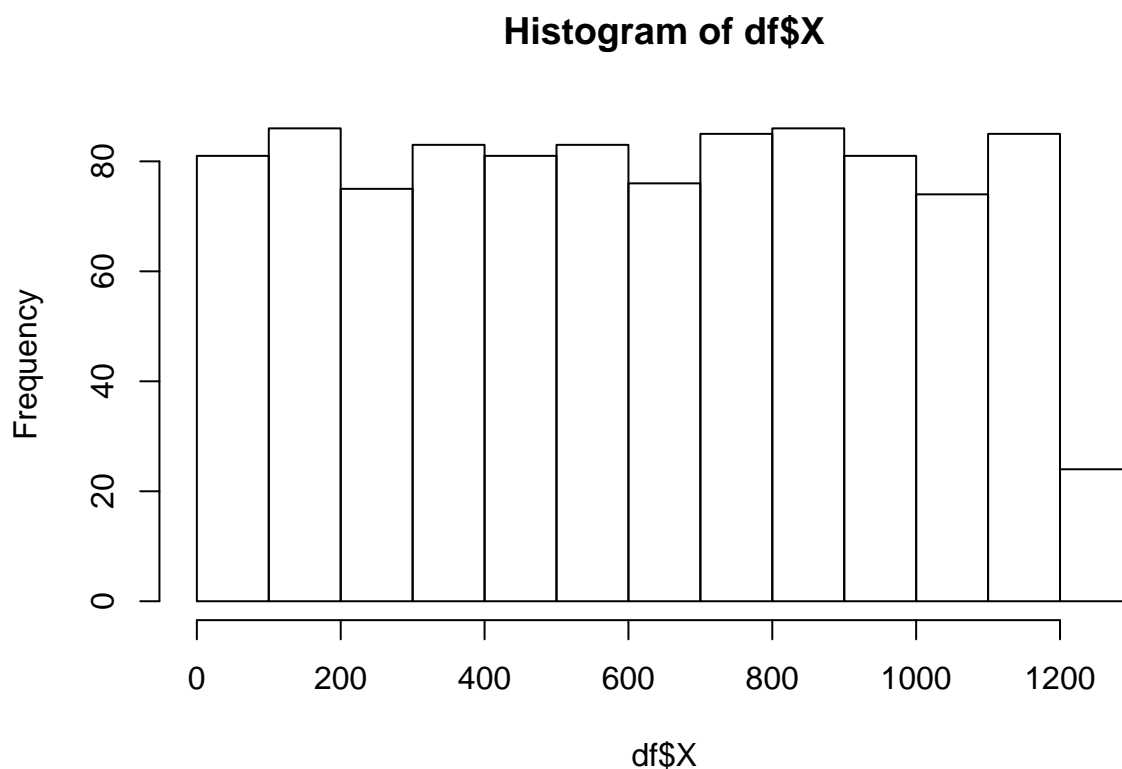
```
## Loading required package: lattice
## Loading required package: survival
## Loading required package: Formula
## Loading required package: ggplot2
##
## Attaching package: 'Hmisc'
## The following objects are masked from 'package:base':
##
##      format.pval, round.POSIXt, trunc.POSIXt, units
```

## X Variable

```
describe(df$X)
```

```
## df$X
##      n missing distinct      Info      Mean      Gmd      .05      .10
##    1000      0      1000        1    615.4    410.6    62.95    122.90
##      .25      .50      .75      .90      .95
##    308.75    613.00    917.25   1110.30   1174.05
##
## lowest :      1      2      3      4      5, highest: 1225 1226 1228 1229 1230
```

```
hist(df$X)
```



#### Gender Variable

```
describe(df$Gender)
```

```
## df$Gender
##      n missing distinct
##  1000      0         2
##
## Value      F      M
## Frequency  505  495
## Proportion 0.505 0.495
```

#### Class.Year Variable

```
describe(df$Class.Year)
```

```
## df$Class.Year
##      n missing distinct    Info    Mean    Gmd
##  1000      0         5  0.949  1996  15.07
##
## Value      1972  1982  1992  2002  2012
## Frequency   105   176   203   223   293
## Proportion 0.105 0.176 0.203 0.223 0.293
```

```
describe(df$Years.Since.Graduation)
```

```
## df$Years.Since.Graduation
##      n missing distinct      Info      Mean      Gmd
##    1000      0         5    0.949    20.77    15.07
##
## Value      5    15    25    35    45
## Frequency  293   223   203   176   105
## Proportion 0.293 0.223 0.203 0.176 0.105
```

### Marital.Status Variable

```
describe(df$Marital.Status)
```

```
## df$Marital.Status
##      n missing distinct
##    1000      0         4
##
## Value      D      M      S      W
## Frequency   61   584   344   11
## Proportion 0.061 0.584 0.344 0.011
```

### Major Variable

```
describe(df$Major)
```

```
## df$Major
##      n missing distinct
##    1000      0         45
##
## lowest : American Studies      Anthropology      Art      Biology      Chemist:
## highest: Spanish              Speech (Drama, etc.) Speech Correction  Theatre      Zoology
```

### Next.Degree Variable

```
describe(df$Next.Degree)
```

```
## df$Next.Degree
##      n missing distinct
##    1000      0         47
##
## lowest : AA   BA   BAE  BD   BFA , highest: UBDS UDDS UMD  UMDS UNKD
```

### AttendanceEvent Variable

```
describe(df$AttendanceEvent)
```

```
## df$AttendanceEvent
##      n missing distinct
##    1000      0         2
```

```
##
## Value      0      1
## Frequency  395   605
## Proportion 0.395 0.605
```

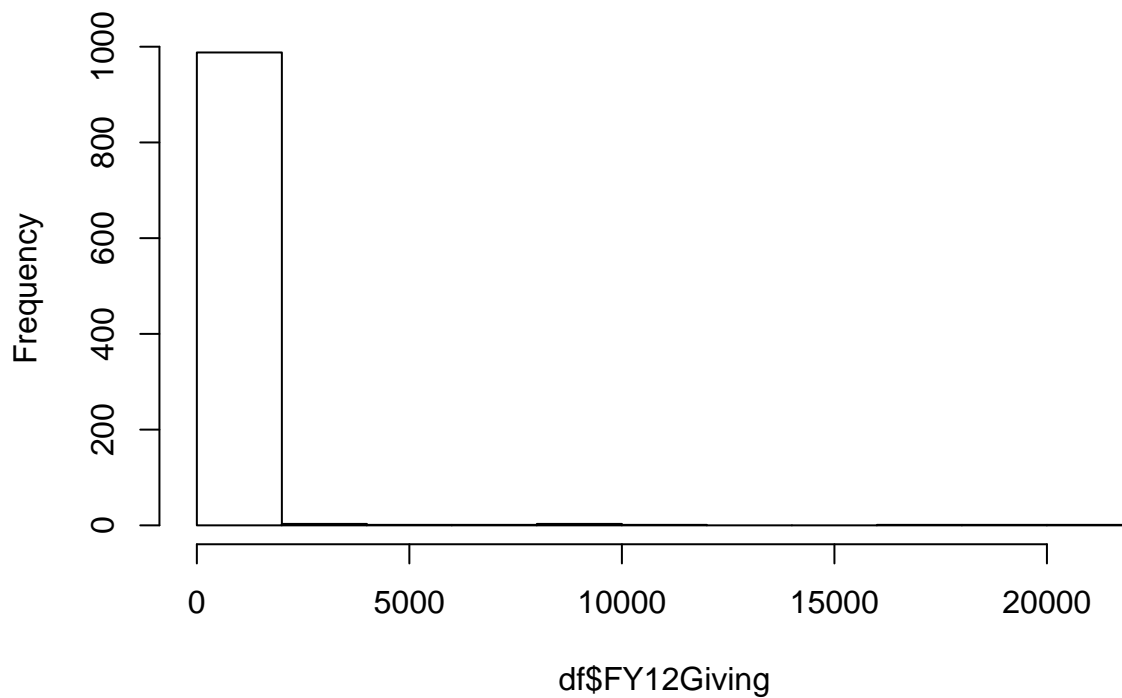
### FY12Giving Variable

```
describe(df$FY12Giving)
```

```
## df$FY12Giving
##      n missing distinct      Info      Mean      Gmd      .05      .10
##   1000       0       66   0.826   186.9   345.5       0       0
##    .25    .50    .75    .90    .95
##      0      0      60    200    350
##
## lowest :      0.00      5.00      6.50      7.00      8.00
## highest: 10000.00 12000.00 16959.99 20000.00 21000.00
```

```
hist(df$FY12Giving)
```

### Histogram of df\$FY12Giving



### FY13Giving Variable

```
describe(df$FY13Giving)
```

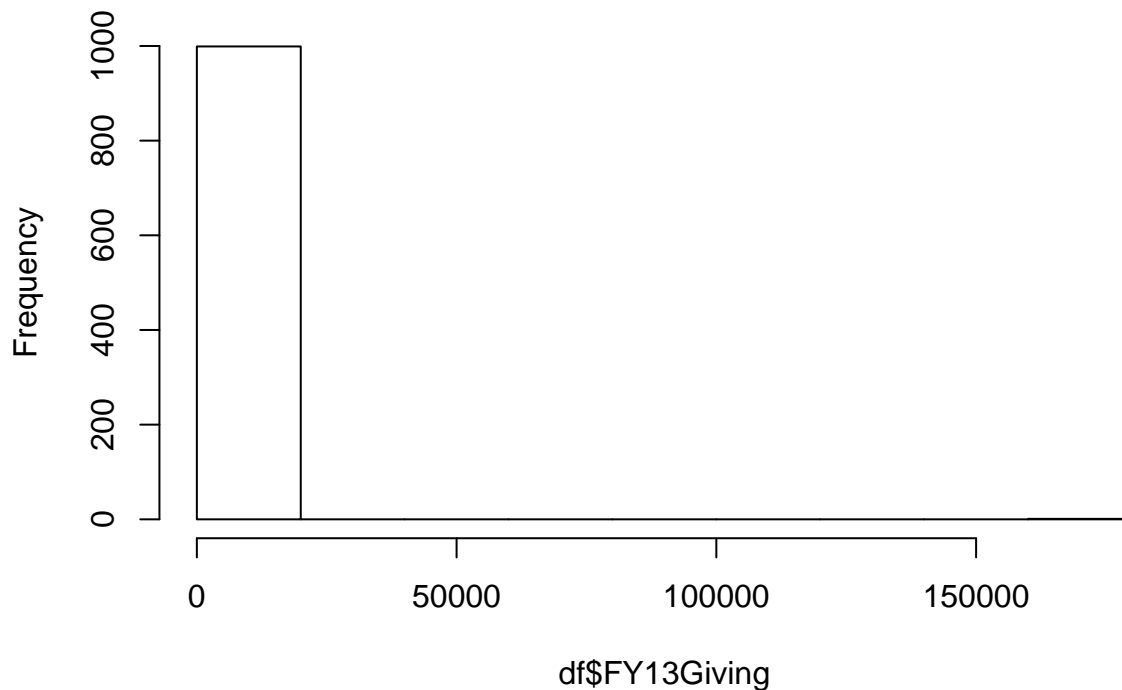
```
## df$FY13Giving
```



```
##      n missing distinct      Info      Mean      Gmd      .05      .10
##    1000      0       78    0.864    311.5    590.4      0.0      0.0
##      .25      .50      .75      .90      .95
##      0.0      0.0     75.0    210.5    400.0
##
## Value      0      500    1000    1500    2000    2500    3000    5000    5500
## Frequency    920     48     13      4      2      3      2      2      1
## Proportion  0.920  0.048  0.013  0.004  0.002  0.003  0.002  0.002  0.001
##
## Value      8000   12000   13000   14500  161500
## Frequency      1       1       1       1       1
## Proportion  0.001  0.001  0.001  0.001  0.001
```

```
hist(df$FY13Giving)
```

## Histogram of df\$FY13Giving

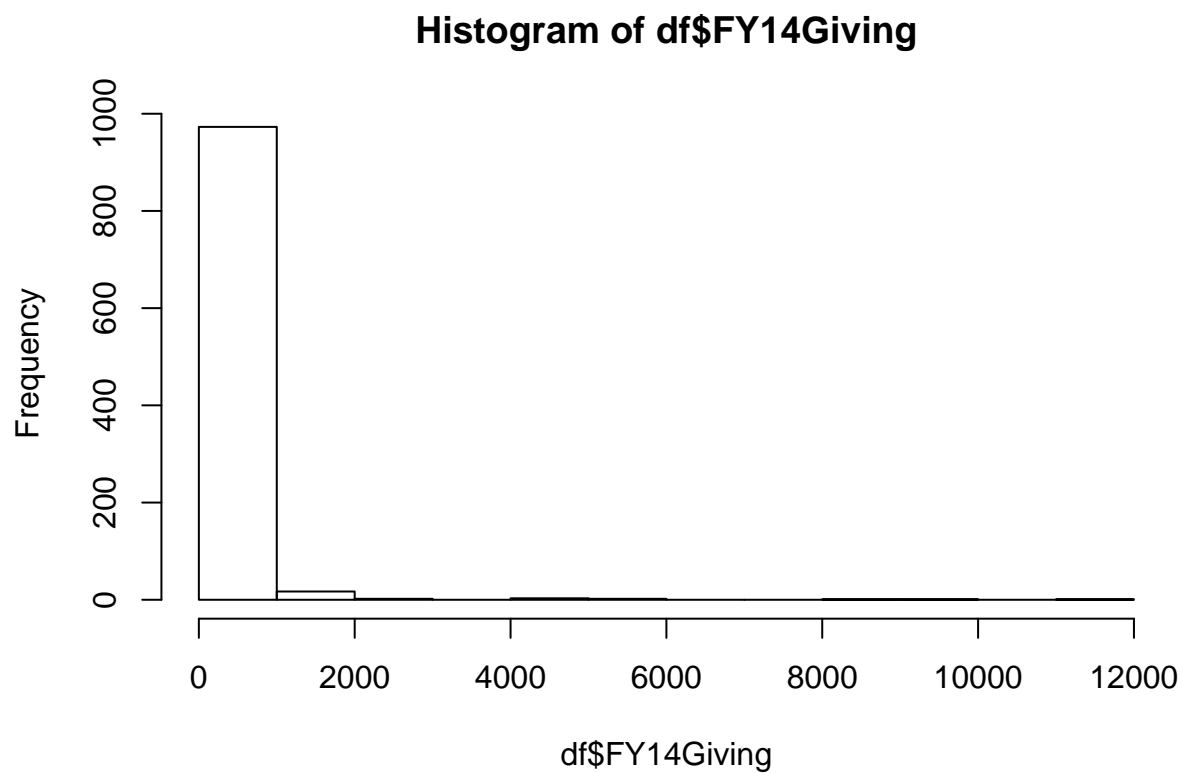


```
### FY14Giving Variable
```

```
describe(df$FY14Giving)
```

```
## df$FY14Giving
##      n missing distinct      Info      Mean      Gmd      .05      .10
##    1000      0       80    0.83    142.6    255.5      0      0
##      .25      .50      .75      .90      .95
##      0       0       50     200     450
##
## lowest :      0.00      1.00      5.00      8.00     10.00
## highest: 5000.00 6000.00 8031.00 10000.00 11187.26
```

```
hist(df$FY14Giving)
```



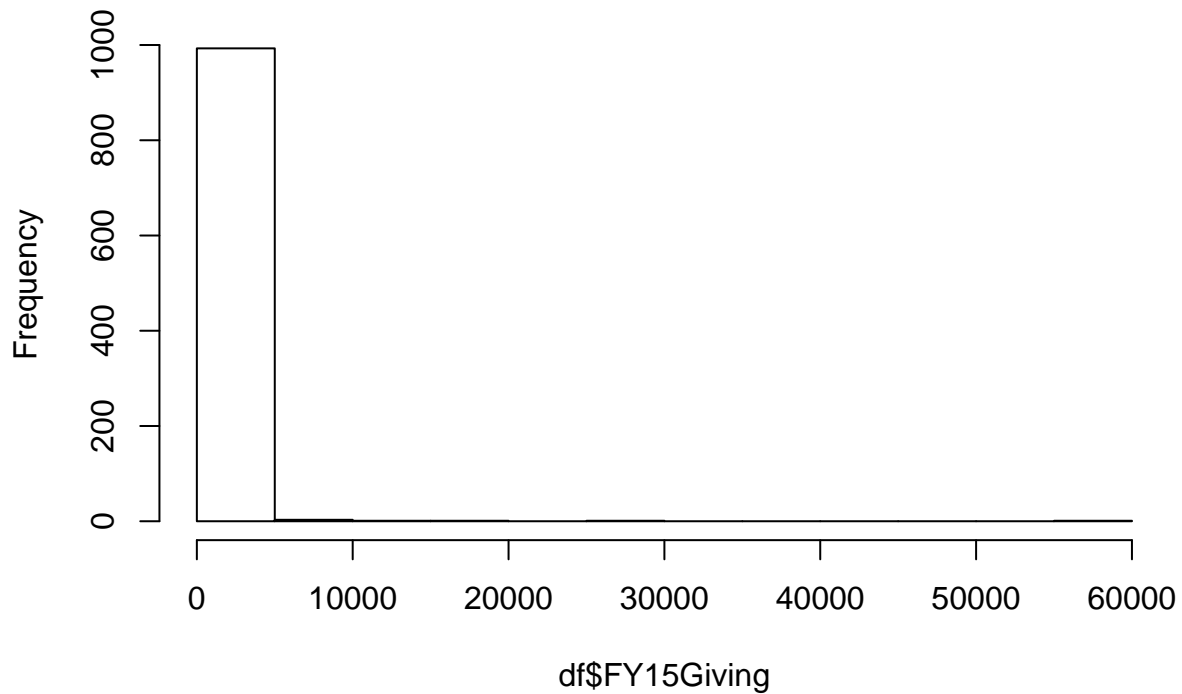
### FY15Giving Variable

```
describe(df$FY15Giving)
```

```
## df$FY15Giving
##      n missing distinct    Info  Mean   Gmd   .05   .10
##  1000      0       62  0.817  252.2  470.7   0.0   0.0
##   .25   .50   .75   .90   .95
##   0.0   0.0  75.0  200.0  538.3
##
## lowest :    0.0    5.0   10.0   13.0   15.0
## highest: 10000.0 14776.0 15634.5 26500.0 58785.5
```

```
hist(df$FY15Giving)
```

## Histogram of df\$FY15Giving



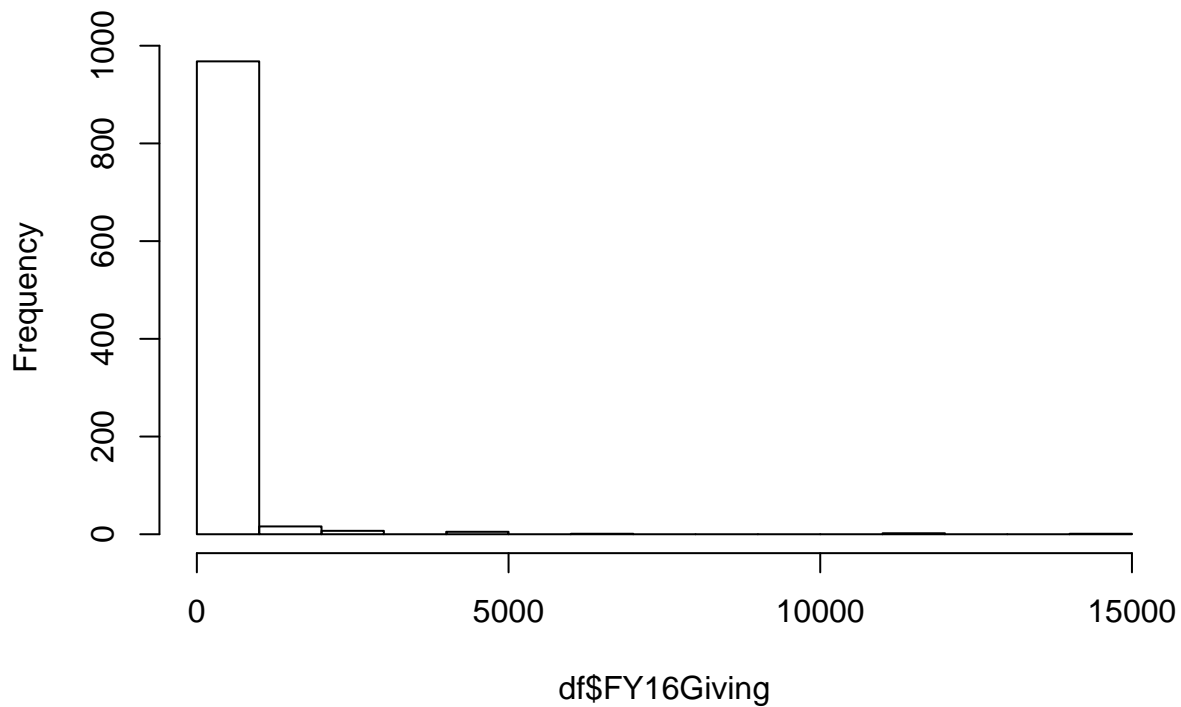
## FY16Giving Variable

```
describe(df$FY16Giving)
```

```
## df$FY16Giving
##      n missing distinct      Info      Mean      Gmd      .05      .10
##  1000         0        71    0.798      170    308.2         0         0
##    .25      .50      .75      .90      .95
##      0         0        75      216      500
##
## lowest :      0.00      5.00     10.00     15.00     18.00
## highest: 5000.00 6500.00 11500.00 11505.84 14655.25
```

```
hist(df$FY16Giving)
```

## Histogram of df\$FY16Giving



### FY16Givingcategory Variable

```
describe(df$FY16GivingCat)
```

```
## df$FY16GivingCat
##      n  missing distinct
##   1000      0         5
##
## Value      [0,1)    [1,100)  [100,250)  [250,500)  [500,2e+05)
## Frequency      586      173      143        39        59
## Proportion     0.586     0.173     0.143     0.039     0.059
```

## EDA

```
describe(df)
```

```
## df
##
## 14 Variables      1000 Observations
## -----
## X
##      n  missing distinct    Info    Mean    Gmd    .05    .10
##   1000      0      1000        1   615.4   410.6   62.95  122.90
```

```

##      .25      .50      .75      .90      .95
##    308.75    613.00    917.25    1110.30    1174.05
##
## lowest :      1      2      3      4      5, highest: 1225 1226 1228 1229 1230
## -----
## Gender
##      n missing distinct
##    1000      0      2
##
## Value      F      M
## Frequency    505    495
## Proportion 0.505 0.495
## -----
## Class.Year
##      n missing distinct      Info      Mean      Gmd
##    1000      0      5    0.949    1996    15.07
##
## Value      1972    1982    1992    2002    2012
## Frequency    105    176    203    223    293
## Proportion 0.105 0.176 0.203 0.223 0.293
## -----
## Marital.Status
##      n missing distinct
##    1000      0      4
##
## Value      D      M      S      W
## Frequency    61    584    344    11
## Proportion 0.061 0.584 0.344 0.011
## -----
## Major
##      n missing distinct
##    1000      0      45
##
## lowest : American Studies      Anthropology      Art      Biology      Chemist:
## highest: Spanish      Speech (Drama, etc.) Speech Correction      Theatre      Zoology
## -----
## Next.Degree
##      n missing distinct
##    1000      0      47
##
## lowest : AA      BA      BAE      BD      BFA , highest: UBDS UDDS UMD      UMDS UNKD
## -----
## AttendanceEvent
##      n missing distinct
##    1000      0      2
##
## Value      0      1
## Frequency    395    605
## Proportion 0.395 0.605
## -----
## FY12Giving
##      n missing distinct      Info      Mean      Gmd      .05      .10
##    1000      0      66    0.826    186.9    345.5      0      0
##      .25      .50      .75      .90      .95

```

```

##          0          0          60          200          350
##
## lowest :          0.00          5.00          6.50          7.00          8.00
## highest: 10000.00 12000.00 16959.99 20000.00 21000.00
## -----
## FY13Giving
##          n missing distinct          Info          Mean          Gmd          .05          .10
##        1000          0          78          0.864          311.5          590.4          0.0          0.0
##          .25          .50          .75          .90          .95
##          0.0          0.0          75.0          210.5          400.0
##
## Value          0          500          1000          1500          2000          2500          3000          5000          5500
## Frequency          920          48          13          4          2          3          2          2          1
## Proportion 0.920 0.048 0.013 0.004 0.002 0.003 0.002 0.002 0.001
##
## Value          8000          12000          13000          14500          161500
## Frequency          1          1          1          1          1
## Proportion 0.001 0.001 0.001 0.001 0.001
## -----
## FY14Giving
##          n missing distinct          Info          Mean          Gmd          .05          .10
##        1000          0          80          0.83          142.6          255.5          0          0
##          .25          .50          .75          .90          .95
##          0          0          50          200          450
##
## lowest :          0.00          1.00          5.00          8.00          10.00
## highest: 5000.00 6000.00 8031.00 10000.00 11187.26
## -----
## FY15Giving
##          n missing distinct          Info          Mean          Gmd          .05          .10
##        1000          0          62          0.817          252.2          470.7          0.0          0.0
##          .25          .50          .75          .90          .95
##          0.0          0.0          75.0          200.0          538.3
##
## lowest :          0.0          5.0          10.0          13.0          15.0
## highest: 10000.0 14776.0 15634.5 26500.0 58785.5
## -----
## FY16Giving
##          n missing distinct          Info          Mean          Gmd          .05          .10
##        1000          0          71          0.798          170          308.2          0          0
##          .25          .50          .75          .90          .95
##          0          0          75          216          500
##
## lowest :          0.00          5.00          10.00          15.00          18.00
## highest: 5000.00 6500.00 11500.00 11505.84 14655.25
## -----
## Years.Since.Graduation
##          n missing distinct          Info          Mean          Gmd
##        1000          0          5          0.949          20.77          15.07
##
## Value          5          15          25          35          45
## Frequency          293          223          203          176          105
## Proportion 0.293 0.223 0.203 0.176 0.105
## -----

```

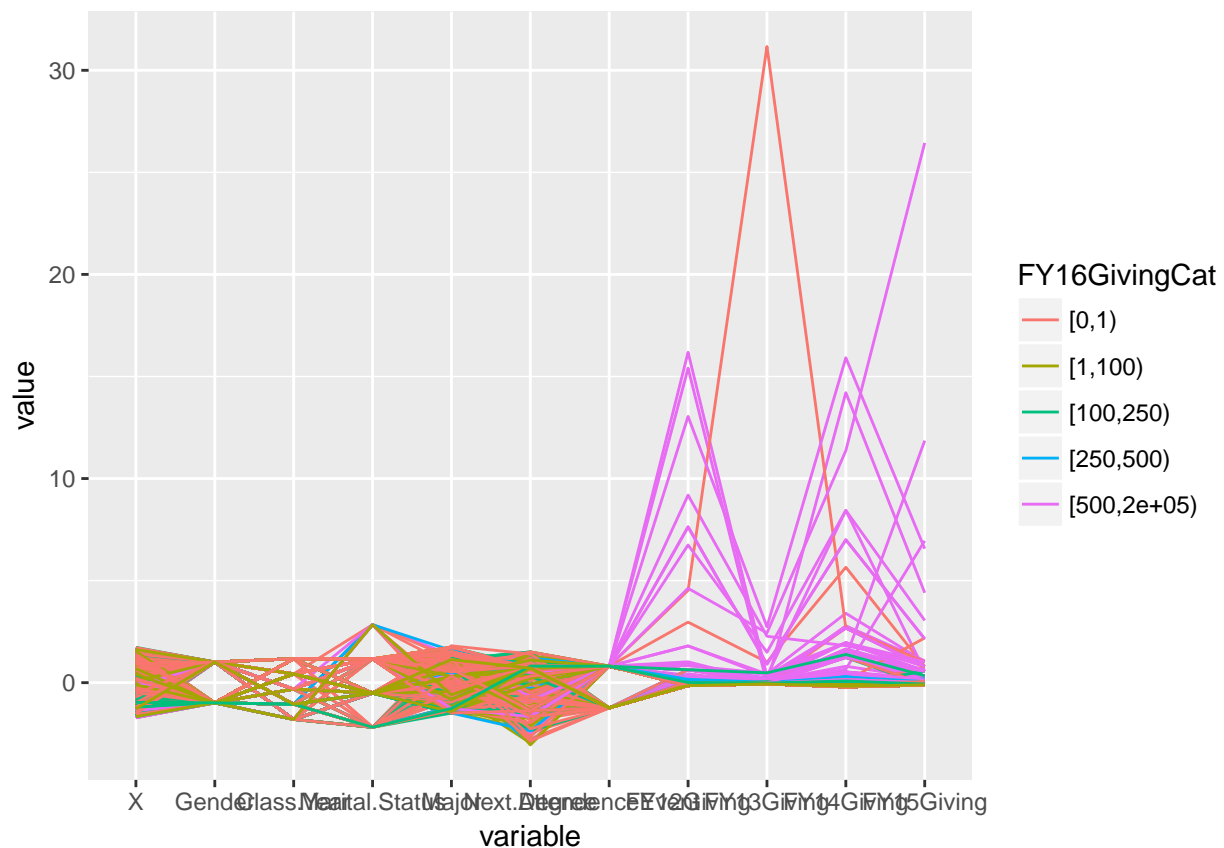
```
## FY16GivingCat
##      n missing distinct
##    1000      0        5
##
## Value      [0,1)      [1,100)      [100,250)      [250,500)      [500,2e+05)
## Frequency      586        173        143          39          59
## Proportion      0.586      0.173      0.143      0.039      0.059
## -----
```

## Parallel Coordinate

```
library(GGally)
```

```
## Warning: package 'GGally' was built under R version 3.4.2
```

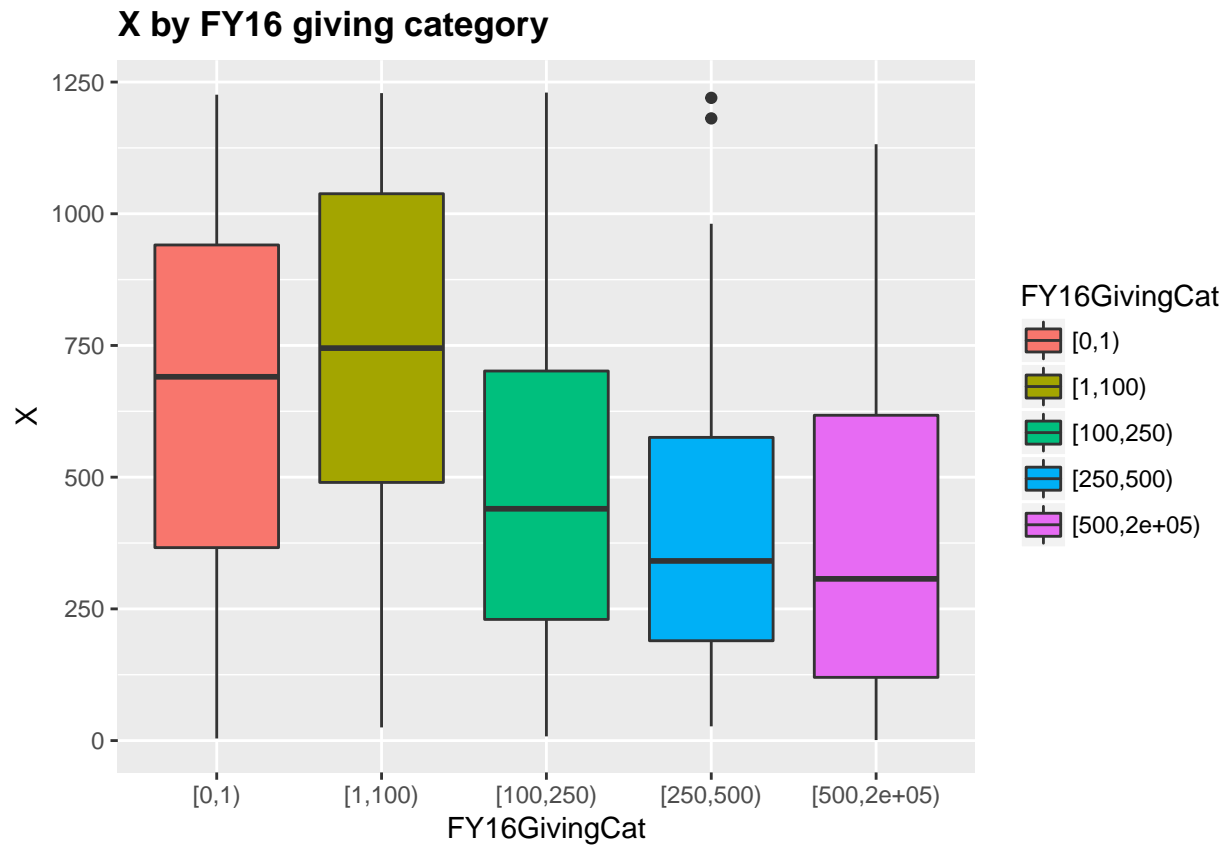
```
ggparcoord(df, columns = 1:(ncol(df) - 3), groupColumn = 14, scale = "std", scaleSummary = "mean")
```



```
#ggparcoord(df, , groupColumn = NULL,
# scale = "std", scaleSummary = "mean", centerObsID = 1,
# missing = "exclude", order = columns, showPoints = FALSE,
# splineFactor = FALSE, alphaLines = 1, boxplot = FALSE,
# shadeBox = NULL, mapping = NULL, title = "")
```

## X Variable

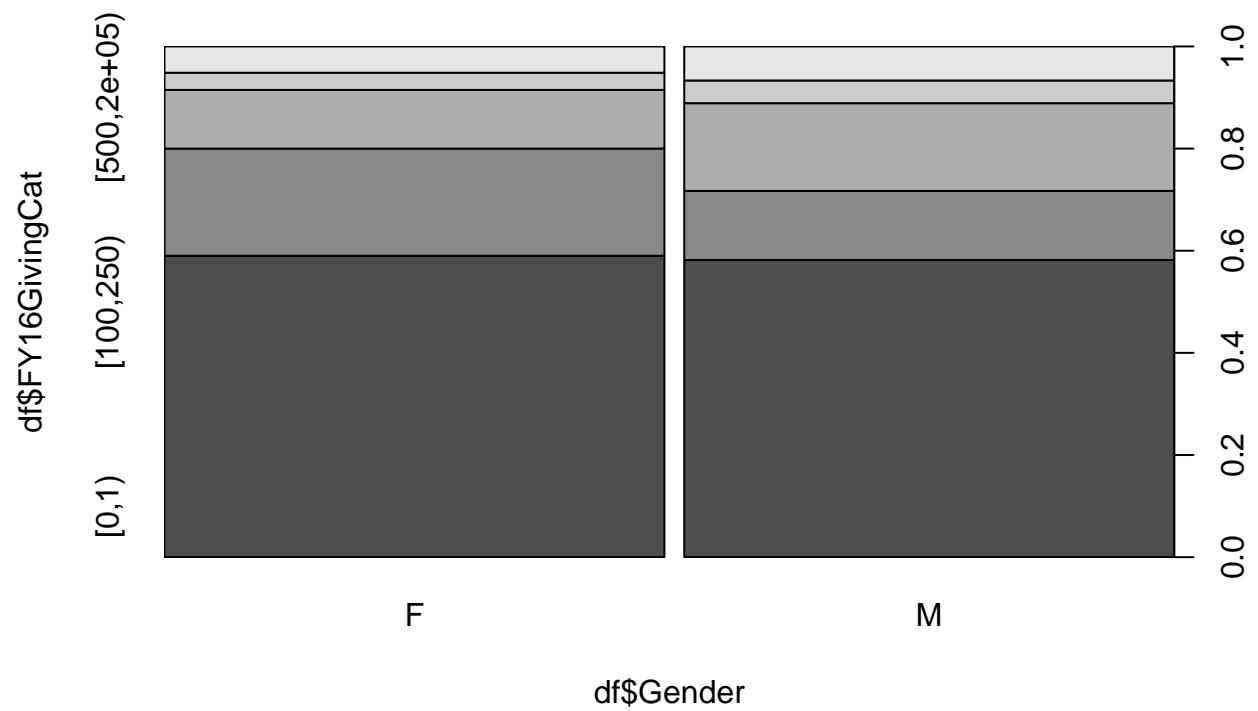
```
ggplot(df, aes(FY16GivingCat, X)) +  
  geom_boxplot(aes(fill = FY16GivingCat)) +  
  ggtitle("X by FY16 giving category") +  
  theme(plot.title = element_text(lineheight=1, face="bold"))
```



## Gender Variable

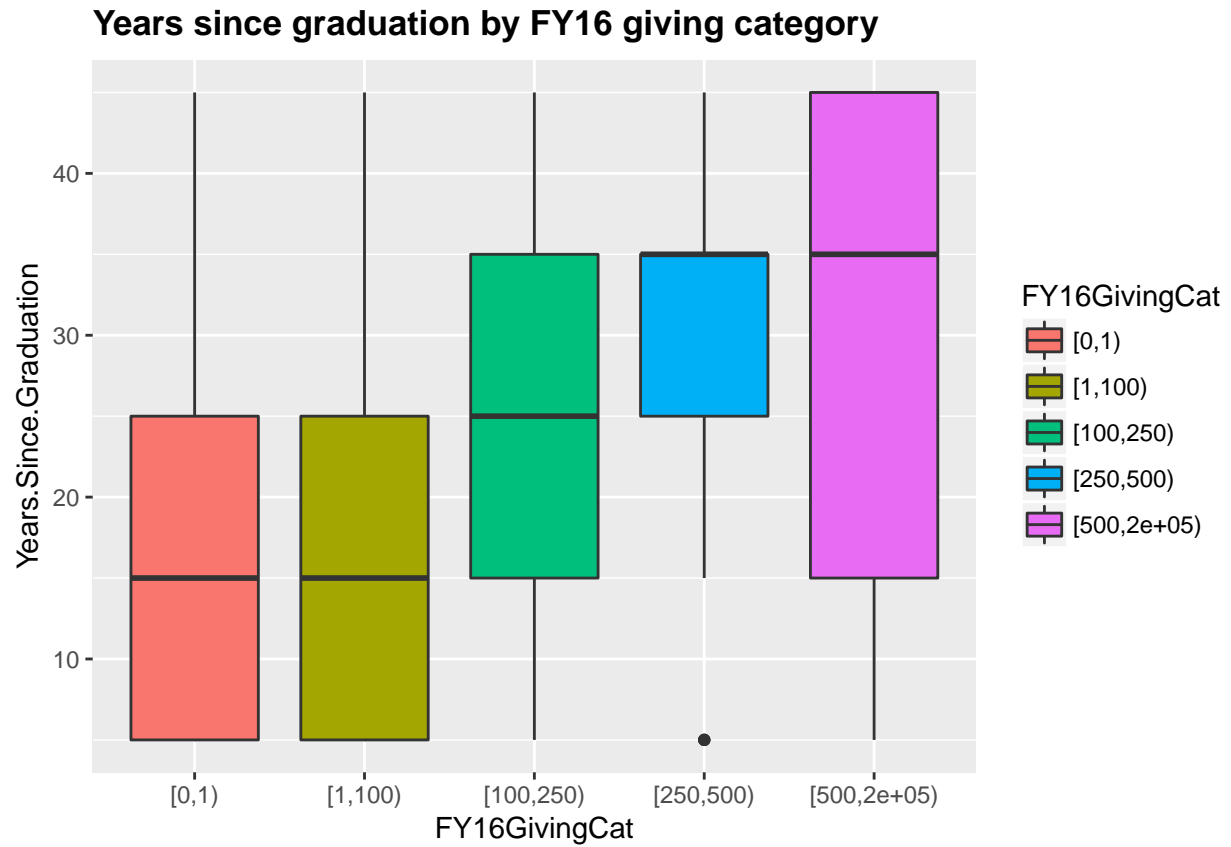
```
spineplot(df$Gender, df$FY16GivingCat)
```





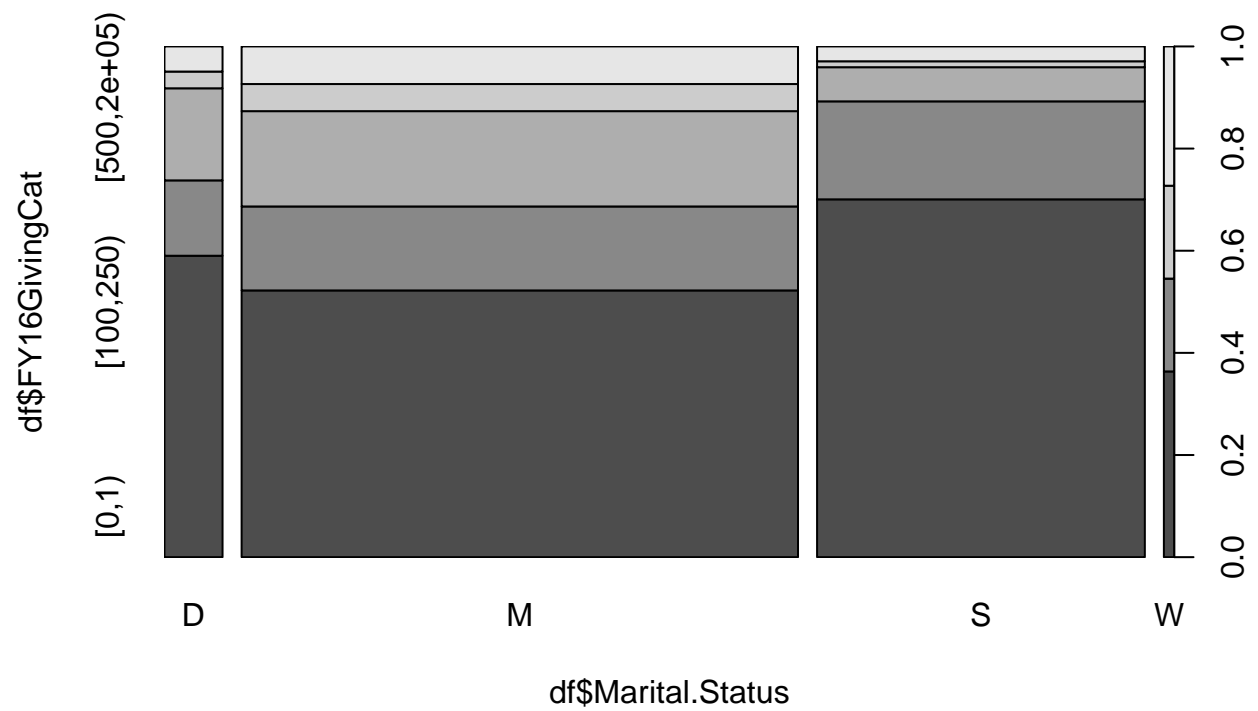
## Years.Since.Graduation Variable

```
ggplot(df, aes(FY16GivingCat, Years.Since.Graduation)) +
  geom_boxplot(aes(fill = FY16GivingCat)) +
  ggtitle("Years since graduation by FY16 giving category") +
  theme(plot.title = element_text(lineheight=1, face="bold"))
```



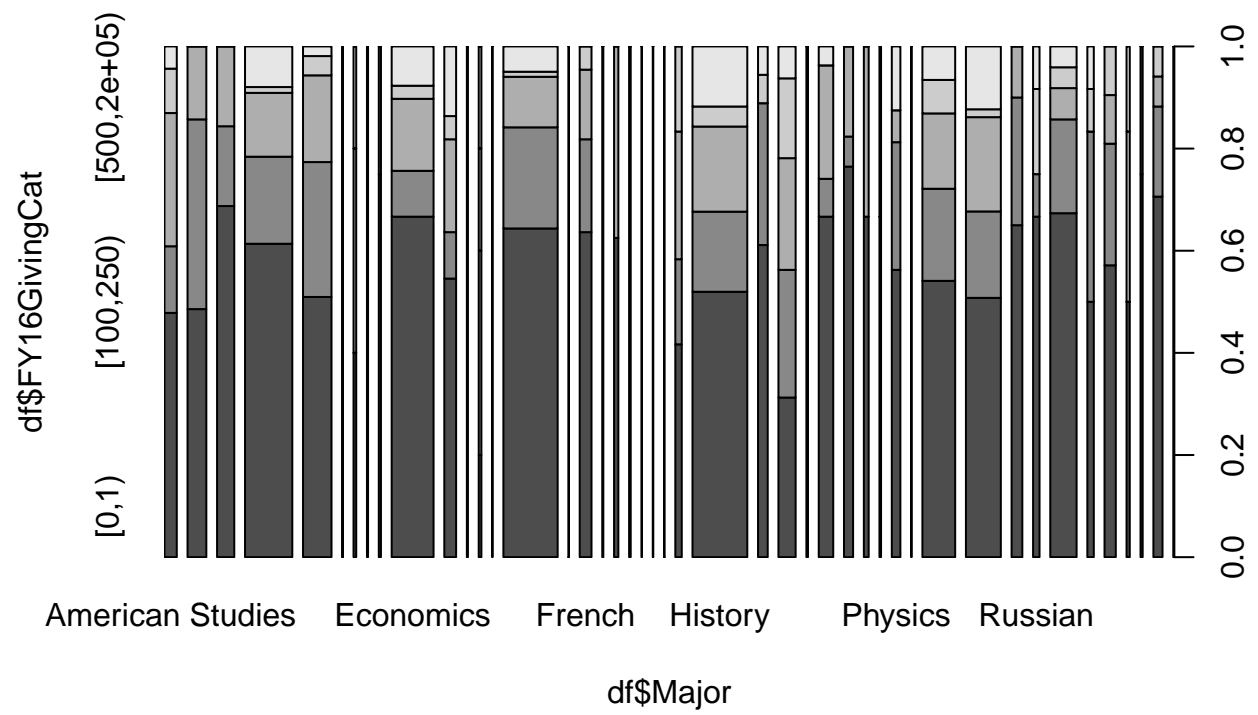
## Marital.Status Variable

```
spineplot(df$Marital.Status, df$FY16GivingCat)
```



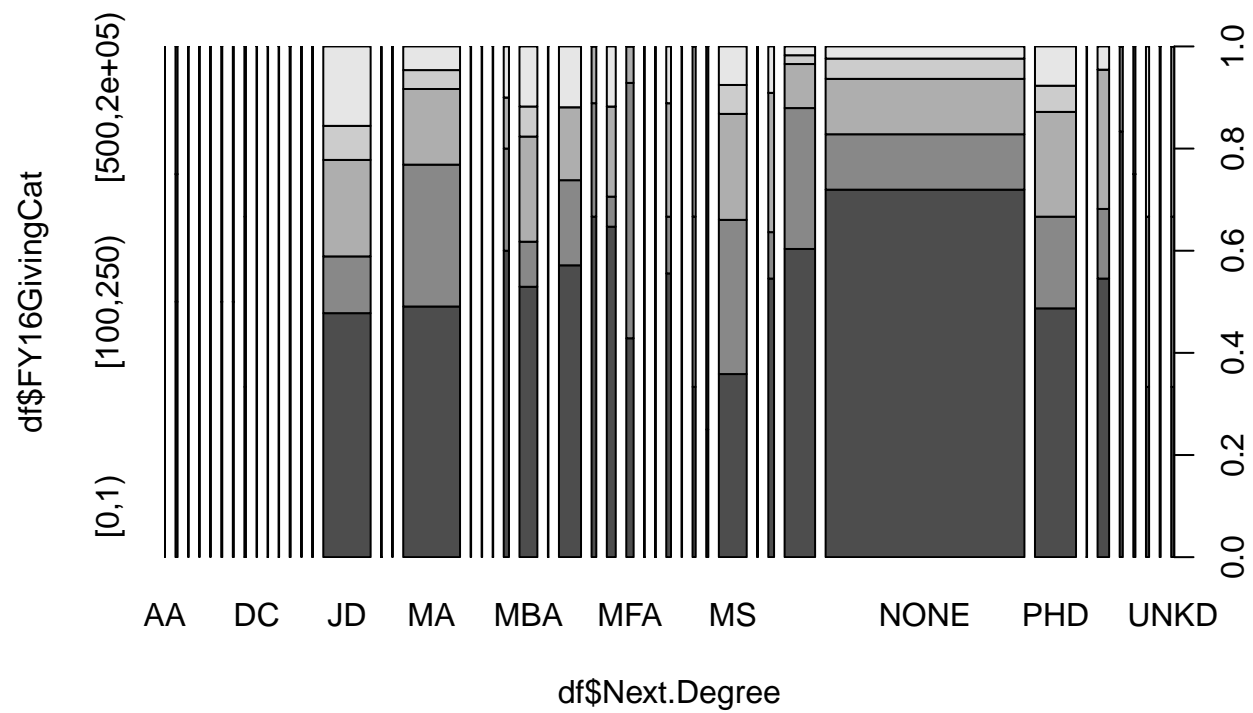
Major Variable

```
spineplot(df$Major, df$FY16GivingCat)
```



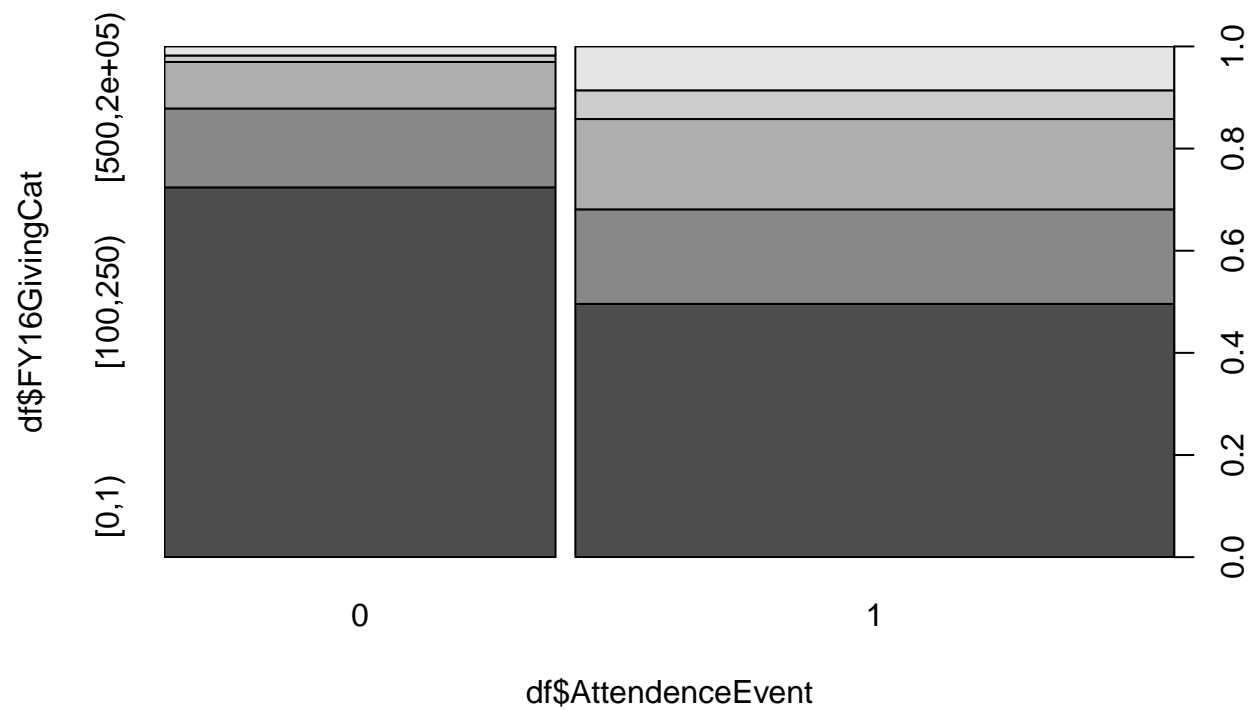
Next.Degree Variable

```
spineplot(df$Next.Degree, df$FY16GivingCat)
```



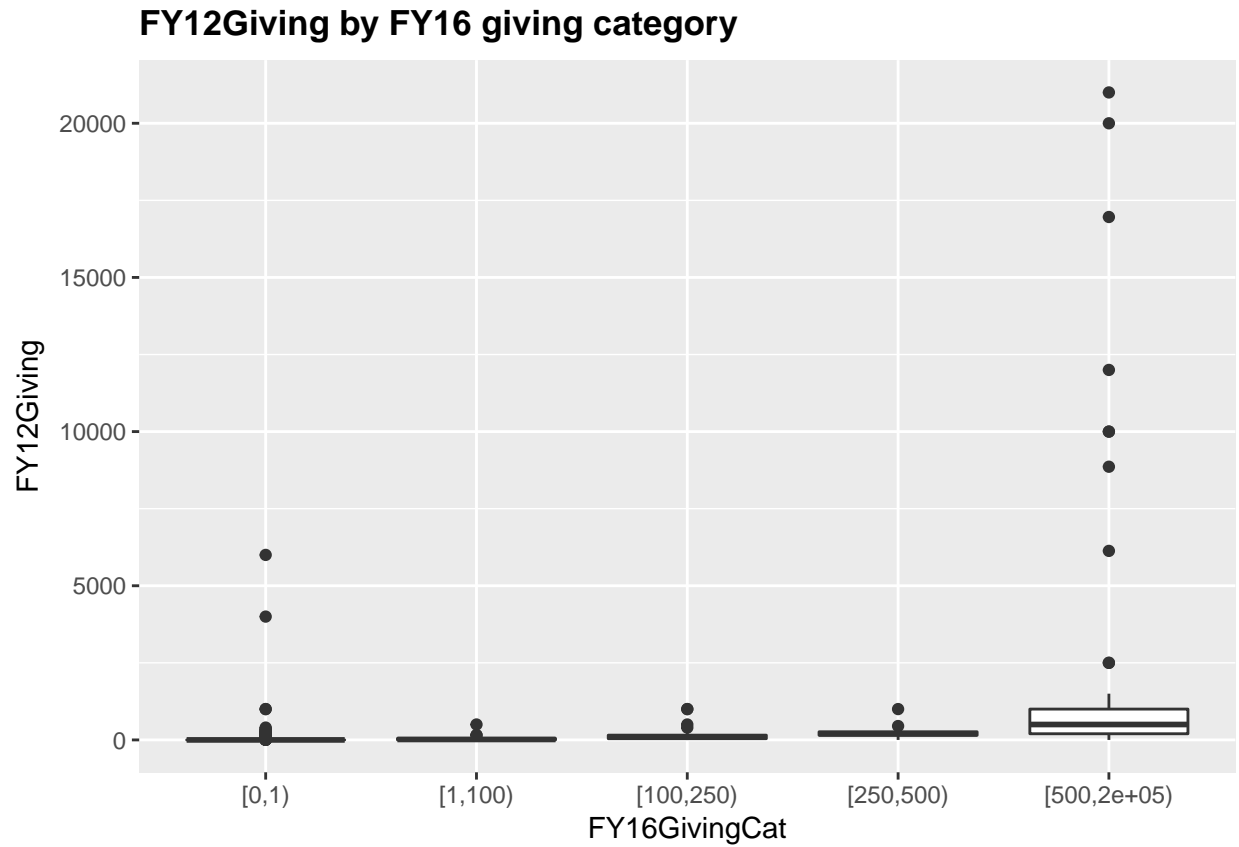
### AttendanceEvent Variable

```
spineplot(df$AttendanceEvent, df$FY16GivingCat)
```



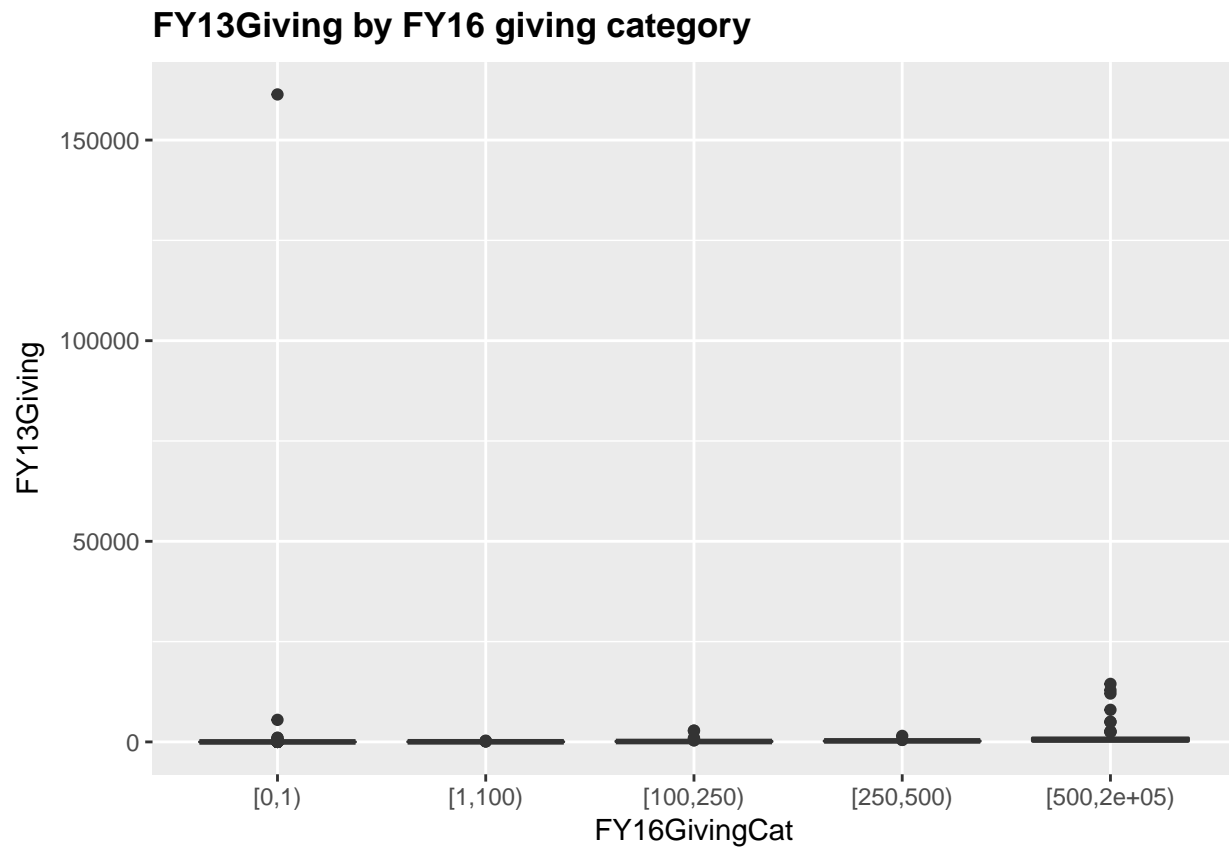
### FY12Giving Variable

```
ggplot(df, aes(FY16GivingCat, FY12Giving)) +
  geom_boxplot(aes(fill = FY12Giving)) +
  ggtitle("FY12Giving by FY16 giving category") +
  theme(plot.title = element_text(lineheight=1, face="bold"))
```



### FY13Giving Variable

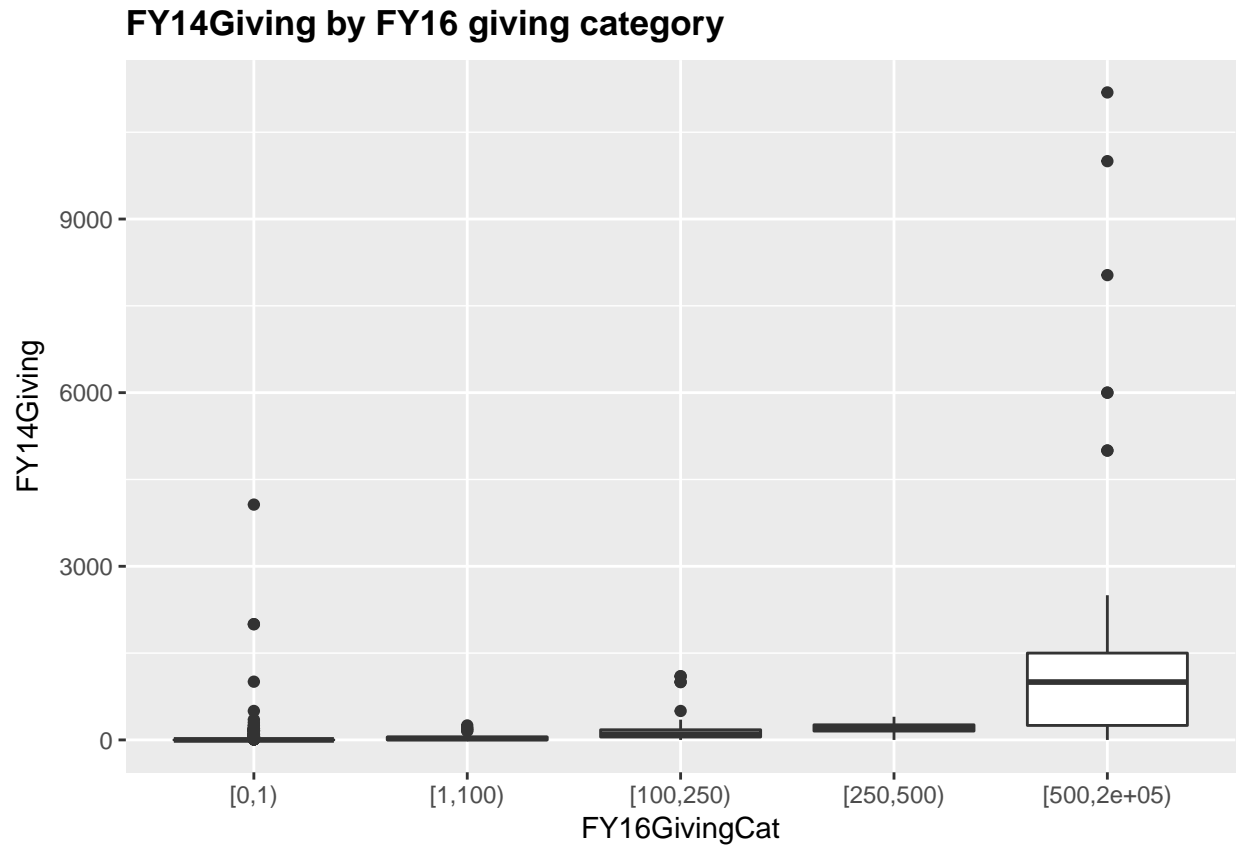
```
ggplot(df, aes(FY16GivingCat, FY13Giving)) +
  geom_boxplot(aes(fill = FY13Giving)) +
  ggtitle("FY13Giving by FY16 giving category") +
  theme(plot.title = element_text(lineheight=1, face="bold"))
```



## FY14Giving Variable

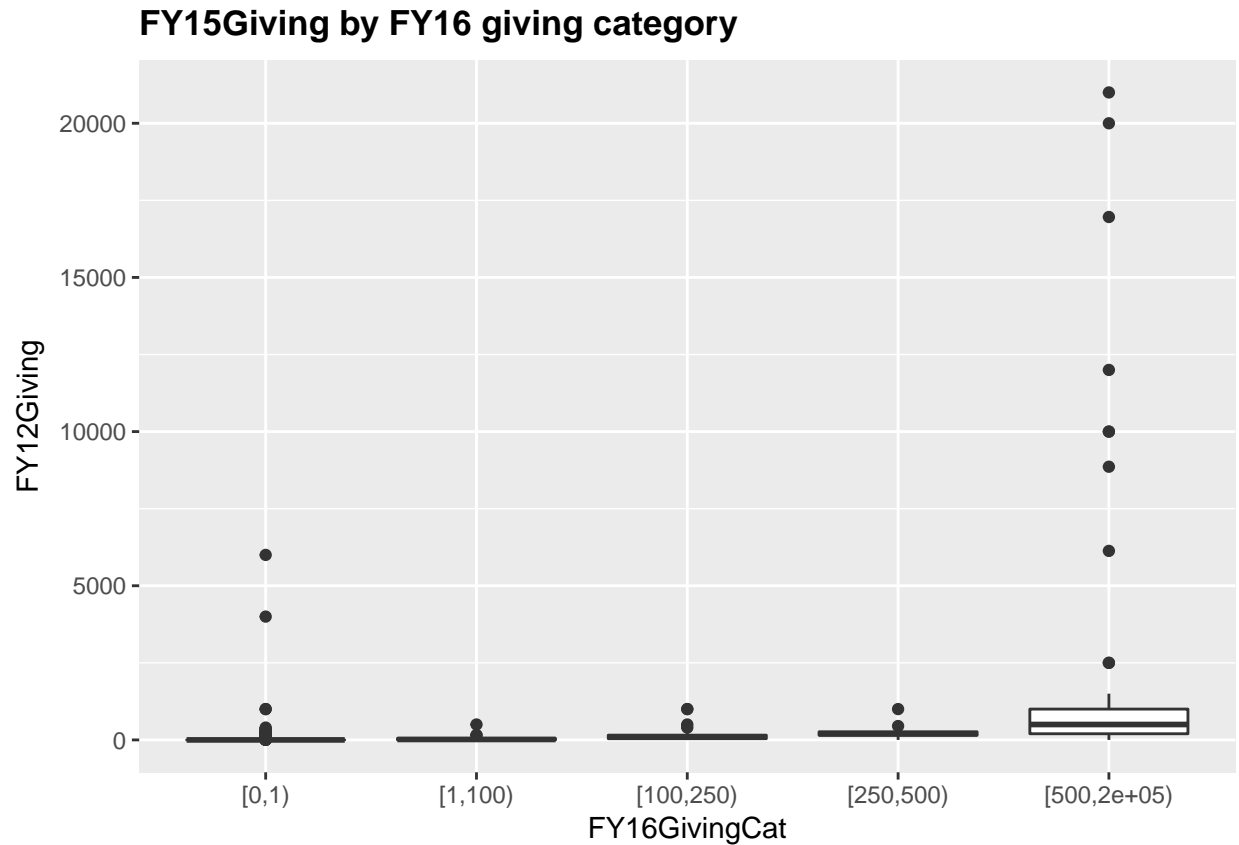
```
ggplot(df, aes(FY16GivingCat, FY14Giving)) +
  geom_boxplot(aes(fill = FY14Giving)) +
  ggtitle("FY14Giving by FY16 giving category") +
  theme(plot.title = element_text(lineheight=1, face="bold"))
```





### FY15Giving Variable

```
ggplot(df, aes(FY16GivingCat, FY12Giving)) +
  geom_boxplot(aes(fill = FY15Giving)) +
  ggtitle("FY15Giving by FY16 giving category") +
  theme(plot.title = element_text(lineheight=1, face="bold"))
```



## Models

```
summary(df)
```

```
##          X          Gender    Class.Year    Marital.Status
##  Min.   :   1.0    F:505    Min.   :1972    D: 61
## 1st Qu.: 308.8    M:495    1st Qu.:1982    M:584
## Median : 613.0                    Median :2002    S:344
## Mean   : 615.4                    Mean   :1996    W: 11
## 3rd Qu.: 917.2                    3rd Qu.:2012
## Max.   :1230.0                    Max.   :2012
##
##          Major    Next.Degree  AttendanceEvent  FY12Giving
## History          :102    NONE    :378    0:395    Min.   :    0.0
## English           :101    MA      :108    1:605    1st Qu.:    0.0
## Biology            : 88    JD       : 90          Median :    0.0
## Economics          : 78    PHD      : 78          Mean   :   186.9
## Psychology         : 65    NDA      : 58          3rd Qu.:    60.0
## Political Science: 61    MS        : 53          Max.   :21000.0
## (Other)            :505    (Other):235
## FY13Giving    FY14Giving    FY15Giving    FY16Giving
## Min.   :    0.0    Min.   :    0.0    Min.   :    0.0    Min.   :    0
## 1st Qu.:    0.0    1st Qu.:    0.0    1st Qu.:    0.0    1st Qu.:    0
## Median :    0.0    Median :    0.0    Median :    0.0    Median :    0
```

```
## Mean : 311.6 Mean : 142.6 Mean : 252.2 Mean : 170
## 3rd Qu.: 75.0 3rd Qu.: 50.0 3rd Qu.: 75.0 3rd Qu.: 75
## Max. :161370.1 Max. :11187.3 Max. :58785.5 Max. :14655
##
## Years.Since.Graduation FY16GivingCat
## Min. : 5.00 [0,1) :586
## 1st Qu.: 5.00 [1,100) :173
## Median :15.00 [100,250) :143
## Mean :20.77 [250,500) : 39
## 3rd Qu.:35.00 [500,2e+05): 59
## Max. :45.00
##
```

## Multinomial Full Model

```
library(package = nnet)
```

```
mod.multinomial <- multinom(data = df, formula = FY16GivingCat ~ X + Marital.Status + Major + Next.Degree
```

```
## # weights: 510 (404 variable)
## initial value 1609.437912
## iter 10 value 1128.941402
## iter 20 value 1061.297257
## iter 30 value 950.837858
## iter 40 value 801.746497
## iter 50 value 777.005764
## iter 60 value 770.454249
## iter 70 value 768.500576
## iter 80 value 767.024873
## iter 90 value 766.197174
## iter 100 value 765.564799
## final value 765.564799
## stopped after 100 iterations
```

```
summary(mod.multinomial)
```

```
## Call:
```

```
## multinom(formula = FY16GivingCat ~ X + Marital.Status + Major +
## Next.Degree + AttendanceEvent + Years.Since.Graduation +
## FY12Giving + FY13Giving + FY14Giving + FY15Giving, data = df)
##
```

```
## Coefficients:
```

```
## (Intercept) X Marital.StatusM Marital.StatusS
## [1,100) 2.523413 0.0008572336 0.09285702 -0.19055120
## [100,250) -9.660664 0.0029468808 0.63331003 -0.01550801
## [250,500) -23.035427 0.0091494040 1.74257092 0.03017217
## [500,2e+05) -4.278929 -0.0018069036 -0.71329132 -0.68557235
## Marital.StatusW MajorAnthropology MajorArt MajorBiology
## [1,100) 0.9099918 1.36529183 -0.3602306 -0.1352438
## [100,250) -8.5013237 -0.09206178 -0.2379120 -1.0877303
## [250,500) 4.4507634 -7.08254515 -11.1212556 -2.3900446
## [500,2e+05) 3.1177688 -7.06844052 -8.5035936 -1.3552525
## MajorChemistry MajorChinese MajorClassics
## [1,100) 0.6759914 -1.536190312 -6.325992
```

|    |             |                                |                              |                  |
|----|-------------|--------------------------------|------------------------------|------------------|
| ## | [100,250)   | -0.3764445                     | 16.055147469                 | 1.188678         |
| ## | [250,500)   | -0.4633606                     | -0.005105401                 | -4.569710        |
| ## | [500,2e+05) | -3.3998696                     | 0.045925468                  | 2.828301         |
| ## |             | MajorComparative Literature    | MajorComputer Science        |                  |
| ## | [1,100)     | -5.539311                      | -7.157957                    |                  |
| ## | [100,250)   | -10.018805                     | -1.427253                    |                  |
| ## | [250,500)   | -6.797910                      | -6.401232                    |                  |
| ## | [500,2e+05) | -2.230179                      | -2.371454                    |                  |
| ## |             | MajorEconomics                 | MajorEconomics-Business      |                  |
| ## | [1,100)     | -0.7386580                     | 0.7342442                    |                  |
| ## | [100,250)   | -0.9608095                     | -1.3439931                   |                  |
| ## | [250,500)   | -2.0441974                     | -2.5680996                   |                  |
| ## | [500,2e+05) | -1.5773319                     | 0.3514056                    |                  |
| ## |             | MajorEconomics-Regional Stds.  | MajorEducation               | MajorEngineering |
| ## | [1,100)     | -8.499595                      | 3.242751                     | -7.6013036       |
| ## | [100,250)   | -12.666760                     | -1.176971                    | -5.7182907       |
| ## | [250,500)   | -7.607976                      | -1.929093                    | -0.3357445       |
| ## | [500,2e+05) | -5.215179                      | -6.406858                    | -1.6040011       |
| ## |             | MajorEnglish                   | MajorEnglish-Journalism      | MajorFrench      |
| ## | [1,100)     | 0.3125381                      | 0.1659683                    | -0.1305775       |
| ## | [100,250)   | -1.2931704                     | 11.3535399                   | -1.0213390       |
| ## | [250,500)   | -2.8208686                     | -4.6443195                   | -1.1903622       |
| ## | [500,2e+05) | -1.1954726                     | -2.2912212                   | -7.5664905       |
| ## |             | MajorGeneral Science           | MajorGeneral Science-Biology |                  |
| ## | [1,100)     | -5.688765                      | -11.6351687                  |                  |
| ## | [100,250)   | -11.133592                     | -0.1271376                   |                  |
| ## | [250,500)   | -1.347656                      | -12.7423633                  |                  |
| ## | [500,2e+05) | -5.909673                      | -4.8385536                   |                  |
| ## |             | MajorGeneral Science-Chemistry | MajorGeneral Science-Math    |                  |
| ## | [1,100)     | -8.005684                      | -4.79811939                  |                  |
| ## | [100,250)   | -7.737567                      | -3.96593343                  |                  |
| ## | [250,500)   | -1.594366                      | -0.05270845                  |                  |
| ## | [500,2e+05) | -3.084328                      | -0.41529132                  |                  |
| ## |             | MajorGeneral Science-Physics   | MajorGeneral Science-Psycho  |                  |
| ## | [1,100)     | -6.1639522                     | -1.23516639                  |                  |
| ## | [100,250)   | -5.8886435                     | 10.02910076                  |                  |
| ## | [250,500)   | -1.8042378                     | -0.09562627                  |                  |
| ## | [500,2e+05) | -0.1805631                     | 0.01078439                   |                  |
| ## |             | MajorGerman                    | MajorHistory                 | MajorIndependent |
| ## | [1,100)     | 0.6124891                      | 0.2769473                    | 0.1384211        |
| ## | [100,250)   | 0.1485638                      | -0.7436847                   | -10.7548003      |
| ## | [250,500)   | 2.2442843                      | -1.7507670                   | -0.3941565       |
| ## | [500,2e+05) | -3.4200321                     | -2.0825209                   | -2.1702166       |
| ## |             | MajorMathematics-Physics       | MajorMusic                   | MajorPhilosophy  |
| ## | [1,100)     | -6.355943                      | -1.0397390                   | -1.1943648       |
| ## | [100,250)   | -14.578112                     | -0.8037523                   | -0.4744509       |
| ## | [250,500)   | -2.359063                      | -9.8751806                   | -9.2271861       |
| ## | [500,2e+05) | -2.655529                      | -9.5921866                   | -7.7079296       |
| ## |             | MajorPhilosophy-Religion       | MajorPhysical Education      | MajorPhysics     |
| ## | [1,100)     | -9.759952                      | -6.6360092                   | 0.3735412        |
| ## | [100,250)   | -1.356991                      | -8.9243825                   | -1.2815097       |
| ## | [250,500)   | -9.649523                      | -0.4767348                   | -6.6392543       |
| ## | [500,2e+05) | -7.336985                      | -15.9474059                  | -1.9153447       |
| ## |             | MajorPol. Sci.-Regional Stds.  | MajorPolitical Science       |                  |

|    |                           |                             |                |                |
|----|---------------------------|-----------------------------|----------------|----------------|
| ## | [1,100)                   | -3.321655443                | 0.5013460      |                |
| ## | [100,250)                 | -9.337793603                | -0.7772198     |                |
| ## | [250,500)                 | -0.002197177                | -0.6187165     |                |
| ## | [500,2e+05)               | -3.705894775                | -1.7205484     |                |
| ## | MajorPsychology           | MajorReligious              | Studies        | MajorRussian   |
| ## | [1,100)                   | 0.2792393                   | 0.5615718      | -1.32856067    |
| ## | [100,250)                 | -0.6819569                  | -0.8102835     | -10.33375269   |
| ## | [250,500)                 | -1.8217454                  | -8.5043969     | 0.98483502     |
| ## | [500,2e+05)               | 0.5466863                   | -7.5702285     | 0.06144011     |
| ## | MajorSociology            | MajorSociology-Anthropology | MajorSpanish   |                |
| ## | [1,100)                   | 0.3066932                   | 1.58067008     | 0.6400035      |
| ## | [100,250)                 | -1.4453565                  | -10.90681717   | -0.7088864     |
| ## | [250,500)                 | -0.8676773                  | 0.07883954     | 0.9603431      |
| ## | [500,2e+05)               | -8.3218859                  | -1.23254732    | -6.6205366     |
| ## | MajorSpeech (Drama, etc.) | MajorSpeech                 | Correction     | MajorTheatre   |
| ## | [1,100)                   | -7.0758126                  | 1.627544       | -0.4911788     |
| ## | [100,250)                 | -10.6664076                 | -9.385912      | -2.2962007     |
| ## | [250,500)                 | 0.8057299                   | -5.207045      | 1.0463268      |
| ## | [500,2e+05)               | -6.5380786                  | -2.664595      | -6.8005813     |
| ## | MajorZoology              | Next.DegreeBA               | Next.DegreeBAE | Next.DegreeBD  |
| ## | [1,100)                   | -5.330156                   | -4.080357      | -8.32563345    |
| ## | [100,250)                 | -4.431612                   | -7.259839      | -2.51529371    |
| ## | [250,500)                 | -1.650792                   | 5.674261       | 0.05038682     |
| ## | [500,2e+05)               | -1.091256                   | -4.133385      | 0.01528931     |
| ## | Next.DegreeBFA            | Next.DegreeBN               | Next.DegreeBS  | Next.DegreeBSN |
| ## | [1,100)                   | -9.6654068                  | -10.508591     | -4.888285      |
| ## | [100,250)                 | -3.4386281                  | 5.161423       | -2.295799      |
| ## | [250,500)                 | -0.1834857                  | -3.016091      | -8.440751      |
| ## | [500,2e+05)               | -5.0416546                  | -3.807964      | 11.029017      |
| ## | Next.DegreeDC             | Next.DegreeDDS              | Next.DegreeDMD | Next.DegreeDO  |
| ## | [1,100)                   | -9.59682575                 | 10.54684181    | 11.9806866     |
| ## | [100,250)                 | -2.64294996                 | -1.06118206    | -0.4389940     |
| ## | [250,500)                 | 0.02368745                  | -0.05962575    | -0.7438335     |
| ## | [500,2e+05)               | -1.77794669                 | -0.22676369    | -0.4553361     |
| ## | Next.DegreeDO2            | Next.DegreeDP               | Next.DegreeJD  | Next.DegreeLLB |
| ## | [1,100)                   | -3.7147796                  | 10.51780914    | -4.841824      |
| ## | [100,250)                 | -2.5732004                  | -0.92879806    | 3.626983       |
| ## | [250,500)                 | -0.7399775                  | -0.01720908    | 6.411624       |
| ## | [500,2e+05)               | -0.8099473                  | -0.07951682    | 3.529526       |
| ## | Next.DegreeLLD            | Next.DegreeMA               | Next.DegreeMA2 | Next.DegreeMAE |
| ## | [1,100)                   | -9.7705363                  | -3.767413      | -9.0315554     |
| ## | [100,250)                 | -4.5350429                  | 3.510430       | -5.2138651     |
| ## | [250,500)                 | -0.9140527                  | 5.913953       | -0.2289857     |
| ## | [500,2e+05)               | -2.3362513                  | 2.454704       | -0.2691576     |
| ## | Next.DegreeMALS           | Next.DegreeMAT              | Next.DegreeMBA | Next.DegreeMCP |
| ## | [1,100)                   | 12.3367945                  | -3.683102      | -5.000928      |
| ## | [100,250)                 | -3.0903689                  | 1.838585       | 4.020933       |
| ## | [250,500)                 | -0.8957007                  | -8.372566      | 5.710182       |
| ## | [500,2e+05)               | -1.1496065                  | 3.670050       | 1.415668       |
| ## | Next.DegreeMD             | Next.DegreeMD2              | Next.DegreeME  | Next.DegreeMFA |
| ## | [1,100)                   | -4.507451                   | -4.269176      | -6.021143      |
| ## | [100,250)                 | 3.370658                    | 2.911181       | 4.057451       |
| ## | [250,500)                 | -6.607033                   | -3.063257      | -10.722116     |
| ## | [500,2e+05)               | 3.182369                    | -4.171633      | 2.598792       |

```

##      Next.DegreeMHA Next.DegreeML Next.DegreeMLS Next.DegreeMM
## [1,100)      -3.265720      0.03889092      -5.142105      -7.4941621
## [100,250)     -2.294172     -0.45890129      3.435932      -3.5131503
## [250,500)     23.440188     -2.70219628     -6.104732     -0.2692473
## [500,2e+05)   -1.184850      3.08333224      3.206018     -0.5777988
##      Next.DegreeMPA Next.DegreeMPH Next.DegreeMS Next.DegreeMSM
## [1,100)      -3.283231      -1.641766      -3.377222      10.5933980
## [100,250)      4.209351      -3.574892      4.014981      -0.7713558
## [250,500)     -4.813642     -3.790106      5.980423      0.0408097
## [500,2e+05)   -3.932118     -3.377313      2.635333     -0.5889781
##      Next.DegreeMSW Next.DegreeNDA Next.DegreeNONE Next.DegreePHD
## [1,100)      -5.291317     -4.396982     -5.296559     -4.252608
## [100,250)      3.916679      3.725240      3.065952      3.424119
## [250,500)     -5.537421      5.396214      5.104815      5.085934
## [500,2e+05)   -1.167043      2.841102      1.301080      1.847227
##      Next.DegreeSTM Next.DegreeTC Next.DegreeUBDS Next.DegreeUDDS
## [1,100)      -0.4166463     -5.025827     -4.884293     -10.828362
## [100,250)     14.9701270      3.178688     -8.209527     -7.070228
## [250,500)     -0.2665349     -15.927059     -10.500101     8.549879
## [500,2e+05)   0.1108964     -5.437222     -3.096209     -4.184922
##      Next.DegreeUMD Next.DegreeUMDS Next.DegreeUNKD
## [1,100)      -2.358429     -9.1360677     -3.040073
## [100,250)     -6.366276     -5.6373934      4.922884
## [250,500)     -1.925520     -2.7980385     -1.442361
## [500,2e+05)   5.231994     -0.7547546     -3.791745
##      AttendanceEvent1 Years.Since.Graduation FY12Giving
## [1,100)      0.2391298      -0.004416789 0.001816831
## [100,250)     0.9930013      0.114594250 0.001435055
## [250,500)     2.2396948      0.289747996 0.007521795
## [500,2e+05)   1.7087060      -0.026553261 0.008881162
##      FY13Giving FY14Giving FY15Giving
## [1,100)      -3.361219e-03 0.001847933 -0.0012363492
## [100,250)     -5.293709e-05 0.005343421 -0.0002853846
## [250,500)     -1.819302e-03 0.003997168 0.0011209901
## [500,2e+05)   -4.128930e-03 0.005403546 0.0023121490
##
## Std. Errors:
##      (Intercept)      X Marital.StatusM Marital.StatusS
## [1,100)      0.015271642 0.0002031158      0.1170874      0.10671967
## [100,250)     0.011616021 0.0002669104      0.1501255      0.12254635
## [250,500)     0.006728752 0.0004566086      0.1076289      0.06672537
## [500,2e+05)   0.006103593 0.0004835245      0.2660940      0.22113686
##      Marital.StatusW MajorAnthropology MajorArt MajorBiology
## [1,100)      1.656521e-02      2.847589e-01 2.512623e-02 0.287475395
## [100,250)      8.032184e-06      1.219641e-01 3.209528e-02 0.277790251
## [250,500)      2.590110e-02      3.018163e-05 6.220947e-06 0.006894269
## [500,2e+05)    1.572940e-02      2.041826e-05 7.409347e-06 0.070364608
##      MajorChemistry MajorChinese MajorClassics
## [1,100)      0.254382607 3.957668e-10 3.389732e-06
## [100,250)      0.192565735 1.013324e-08 1.140031e-02
## [250,500)      0.023478237 6.305338e-10 3.488049e-05
## [500,2e+05)    0.005782162 7.177547e-11 8.879591e-03
##      MajorComparative Literature MajorComputer Science
## [1,100)      5.842695e-06      2.132788e-06

```

|    |             |                                |                              |                  |
|----|-------------|--------------------------------|------------------------------|------------------|
| ## | [100,250)   | 7.786037e-07                   | 1.277521e-03                 |                  |
| ## | [250,500)   | 1.693005e-05                   | 1.658911e-05                 |                  |
| ## | [500,2e+05) | 1.005473e-04                   | 1.486510e-04                 |                  |
| ## |             | MajorEconomics                 | MajorEconomics-Business      |                  |
| ## | [1,100)     | 0.12438195                     | 0.015832975                  |                  |
| ## | [100,250)   | 0.28027148                     | 0.028050406                  |                  |
| ## | [250,500)   | 0.02538289                     | 0.009221901                  |                  |
| ## | [500,2e+05) | 0.03066192                     | 0.013242249                  |                  |
| ## |             | MajorEconomics-Regional        | Stds. MajorEducation         | MajorEngineering |
| ## | [1,100)     | 3.917627e-06                   | 0.0193423839                 | 5.137639e-06     |
| ## | [100,250)   | 3.641855e-07                   | 0.0073248083                 | 1.360765e-05     |
| ## | [250,500)   | 7.119151e-06                   | 0.0212173603                 | 5.513867e-05     |
| ## | [500,2e+05) | 3.913032e-05                   | 0.0000419121                 | 2.818222e-04     |
| ## |             | MajorEnglish                   | MajorEnglish-Journalism      | MajorFrench      |
| ## | [1,100)     | 0.26978918                     | 3.599300e-09                 | 2.236654e-02     |
| ## | [100,250)   | 0.30726204                     | 2.241906e-07                 | 2.119446e-02     |
| ## | [250,500)   | 0.02243799                     | 1.354810e-08                 | 1.506366e-02     |
| ## | [500,2e+05) | 0.04400890                     | 4.376200e-08                 | 2.033226e-05     |
| ## |             | MajorGeneral Science           | MajorGeneral Science-Biology |                  |
| ## | [1,100)     | 2.983759e-06                   | 3.618813e-06                 |                  |
| ## | [100,250)   | 3.477264e-07                   | 1.651298e-02                 |                  |
| ## | [250,500)   | 4.066920e-05                   | 3.302419e-05                 |                  |
| ## | [500,2e+05) | 3.948027e-05                   | 4.442001e-05                 |                  |
| ## |             | MajorGeneral Science-Chemistry | MajorGeneral Science-Math    |                  |
| ## | [1,100)     | 3.180981e-06                   | 5.386087e-06                 |                  |
| ## | [100,250)   | 1.570440e-06                   | 1.176988e-05                 |                  |
| ## | [250,500)   | 1.174431e-04                   | 2.280802e-05                 |                  |
| ## | [500,2e+05) | 1.705032e-04                   | 1.733230e-04                 |                  |
| ## |             | MajorGeneral Science-Physics   | MajorGeneral Science-Psycho  |                  |
| ## | [1,100)     | 3.628157e-06                   | 3.277439e-08                 |                  |
| ## | [100,250)   | 7.223242e-06                   | 3.226358e-07                 |                  |
| ## | [250,500)   | 1.313742e-04                   | 4.178234e-16                 |                  |
| ## | [500,2e+05) | 6.490568e-05                   | 1.047195e-10                 |                  |
| ## |             | MajorGerman                    | MajorHistory                 | MajorIndependent |
| ## | [1,100)     | 1.232183e-02                   | 0.30142435                   | 1.937738e-02     |
| ## | [100,250)   | 1.885352e-02                   | 0.28581200                   | 4.919032e-07     |
| ## | [250,500)   | 1.183877e-02                   | 0.04379056                   | 4.835271e-03     |
| ## | [500,2e+05) | 7.610808e-05                   | 0.03926891                   | 4.149002e-03     |
| ## |             | MajorMathematics-Physics       | MajorMusic                   | MajorPhilosophy  |
| ## | [1,100)     | 1.177007e-05                   | 1.049546e-02                 | 9.200106e-03     |
| ## | [100,250)   | 4.882588e-05                   | 3.504305e-02                 | 2.871676e-02     |
| ## | [250,500)   | 9.166351e-05                   | 7.932882e-06                 | 1.061300e-05     |
| ## | [500,2e+05) | 1.309762e-04                   | 5.610060e-06                 | 2.254156e-05     |
| ## |             | MajorPhilosophy-Religion       | MajorPhysical Education      | MajorPhysics     |
| ## | [1,100)     | 6.439748e-07                   | 7.936492e-06                 | 2.955974e-02     |
| ## | [100,250)   | 1.074351e-02                   | 3.247212e-06                 | 8.960686e-03     |
| ## | [250,500)   | 4.596163e-06                   | 1.671094e-03                 | 5.868671e-06     |
| ## | [500,2e+05) | 2.526323e-05                   | 2.304349e-05                 | 3.980872e-03     |
| ## |             | MajorPol. Sci.-Regional        | Stds. MajorPolitical Science |                  |
| ## | [1,100)     | 1.273579e-05                   | 0.26401060                   |                  |
| ## | [100,250)   | 1.405131e-06                   | 0.20919087                   |                  |
| ## | [250,500)   | 1.104282e-10                   | 0.08569474                   |                  |
| ## | [500,2e+05) | 1.741994e-04                   | 0.01988016                   |                  |
| ## |             | MajorPsychology                | MajorReligious Studies       | MajorRussian     |

|    |                           |                |                             |                |
|----|---------------------------|----------------|-----------------------------|----------------|
| ## | [1,100)                   | 0.23218637     | 1.818325e-02                | 5.075293e-03   |
| ## | [100,250)                 | 0.27149864     | 1.155084e-02                | 1.008177e-06   |
| ## | [250,500)                 | 0.01238954     | 3.547902e-06                | 2.634841e-02   |
| ## | [500,2e+05)               | 0.06778680     | 1.406166e-05                | 1.720625e-02   |
| ## | MajorSociology            | MajorSociology | MajorSociology-Anthropology | MajorSpanish   |
| ## | [1,100)                   | 0.0968897920   | 2.572340e-02                | 2.867700e-02   |
| ## | [100,250)                 | 0.0141037768   | 8.347044e-07                | 1.095390e-02   |
| ## | [250,500)                 | 0.0162627240   | 3.189164e-02                | 9.519633e-03   |
| ## | [500,2e+05)               | 0.0002847582   | 2.548360e-02                | 2.990042e-05   |
| ## | MajorSpeech (Drama, etc.) | MajorSpeech    | Correction                  | MajorTheatre   |
| ## | [1,100)                   | 5.432561e-06   | 7.479616e-03                | 1.784344e-02   |
| ## | [100,250)                 | 8.723329e-07   | 1.249394e-06                | 5.495951e-03   |
| ## | [250,500)                 | 3.032652e-03   | 3.765217e-05                | 1.126641e-02   |
| ## | [500,2e+05)               | 2.103453e-05   | 1.064156e-04                | 5.103754e-05   |
| ## | MajorZoology              | Next.DegreeBA  | Next.DegreeBAE              | Next.DegreeBD  |
| ## | [1,100)                   | 1.447534e-05   | 9.228220e-03                | 2.663540e-05   |
| ## | [100,250)                 | 1.770929e-07   | 4.042173e-07                | 2.014964e-06   |
| ## | [250,500)                 | 3.032762e-07   | 2.326720e-03                | 8.275953e-12   |
| ## | [500,2e+05)               | 2.807370e-05   | 3.410077e-06                | 2.034276e-09   |
| ## | Next.DegreeBFA            | Next.DegreeBN  | Next.DegreeBS               | Next.DegreeBSN |
| ## | [1,100)                   | 5.565375e-05   | 3.326807e-05                | 6.789777e-06   |
| ## | [100,250)                 | 3.657416e-06   | 9.085063e-03                | 4.828488e-08   |
| ## | [250,500)                 | 9.236338e-08   | 3.952705e-07                | 1.887193e-08   |
| ## | [500,2e+05)               | 3.306116e-06   | 6.029077e-06                | 8.050973e-05   |
| ## | Next.DegreeDC             | Next.DegreeDDS | Next.DegreeDMD              | Next.DegreeDO  |
| ## | [1,100)                   | 5.783392e-05   | 2.208357e-08                | 3.198422e-09   |
| ## | [100,250)                 | 5.431058e-06   | 3.858032e-11                | 1.339995e-15   |
| ## | [250,500)                 | 9.037144e-08   | 2.604758e-13                | 1.021209e-12   |
| ## | [500,2e+05)               | 1.709498e-05   | 7.096430e-11                | 3.160080e-11   |
| ## | Next.DegreeDO2            | Next.DegreeDP  | Next.DegreeJD               | Next.DegreeLLB |
| ## | [1,100)                   | 1.443250e-05   | 2.177524e-08                | 0.2319327      |
| ## | [100,250)                 | 1.683677e-07   | 4.615374e-11                | 0.2364231      |
| ## | [250,500)                 | 2.839101e-07   | 5.532658e-13                | 0.1722187      |
| ## | [500,2e+05)               | 2.899115e-05   | 4.638157e-11                | 0.1406218      |
| ## | Next.DegreeLLD            | Next.DegreeMA  | Next.DegreeMA2              | Next.DegreeMAE |
| ## | [1,100)                   | 1.380909e-05   | 0.23616059                  | 1.982851e-05   |
| ## | [100,250)                 | 9.039425e-07   | 0.26103969                  | 3.689745e-07   |
| ## | [250,500)                 | 1.569548e-07   | 0.04833875                  | 1.234268e-11   |
| ## | [500,2e+05)               | 3.273262e-06   | 0.03767496                  | 3.994443e-08   |
| ## | Next.DegreeMALS           | Next.DegreeMAT | Next.DegreeMBA              | Next.DegreeMCP |
| ## | [1,100)                   | 7.008018e-09   | 1.605504e-02                | 0.040470049    |
| ## | [100,250)                 | 9.116705e-12   | 1.224522e-02                | 0.152907942    |
| ## | [250,500)                 | 3.999103e-13   | 7.642943e-09                | 0.033587948    |
| ## | [500,2e+05)               | 4.072711e-11   | 1.175440e-02                | 0.003403899    |
| ## | Next.DegreeMD             | Next.DegreeMD2 | Next.DegreeME               | Next.DegreeMFA |
| ## | [1,100)                   | 1.686566e-01   | 1.468697e-02                | 9.749395e-03   |
| ## | [100,250)                 | 1.494563e-01   | 1.732022e-02                | 4.122593e-02   |
| ## | [250,500)                 | 2.897653e-07   | 2.199846e-07                | 9.315050e-07   |
| ## | [500,2e+05)               | 4.569431e-02   | 2.663724e-06                | 1.371700e-02   |
| ## | Next.DegreeMHA            | Next.DegreeML  | Next.DegreeMLS              | Next.DegreeMM  |
| ## | [1,100)                   | 5.283304e-08   | 4.086782e-08                | 1.154308e-02   |
| ## | [100,250)                 | 6.329757e-11   | 1.260485e-06                | 1.406989e-02   |
| ## | [250,500)                 | 9.390833e-08   | 5.927513e-08                | 1.121892e-07   |
| ## | [500,2e+05)               | 1.958682e-10   | 1.275717e-06                | 1.844500e-03   |



```

##           Next.DegreeMPA Next.DegreeMPH Next.DegreeMS Next.DegreeMSM
## [1,100)      2.069034e-02  7.758475e-03  0.26319595  2.188252e-08
## [100,250)    1.536377e-02  1.909462e-06  0.21226482  5.694167e-11
## [250,500)    1.439757e-07  5.672603e-08  0.06813226  3.826630e-13
## [500,2e+05)  2.201758e-06  4.982470e-06  0.02919090  1.859151e-10
##           Next.DegreeMSW Next.DegreeNDA Next.DegreeNONE Next.DegreePHD
## [1,100)      1.303093e-02  0.28031438  0.1934026  0.27165869
## [100,250)    2.784713e-02  0.07027058  0.2017986  0.26451307
## [250,500)    5.417477e-08  0.01443343  0.2626550  0.05147027
## [500,2e+05)  1.239216e-03  0.01573150  0.0951100  0.03458215
##           Next.DegreeSTM Next.DegreeTC Next.DegreeUBDS Next.DegreeUDDS
## [1,100)      1.551199e-10  4.055323e-02  9.015667e-03  1.904133e-05
## [100,250)    3.220224e-07  3.658894e-02  1.530976e-07  3.274634e-07
## [250,500)    1.958919e-14  8.047018e-08  3.238059e-09  4.020177e-03
## [500,2e+05)  2.130960e-12  6.674794e-03  3.875118e-06  1.301394e-06
##           Next.DegreeUMD Next.DegreeUMDS Next.DegreeUNKD
## [1,100)      2.173402e-02  6.483391e-05  2.365924e-02
## [100,250)    7.294947e-07  9.110864e-07  2.342309e-02
## [250,500)    1.869912e-07  1.849362e-07  2.481430e-07
## [500,2e+05)  9.240604e-03  5.286916e-06  4.071594e-06
##           AttendanceEvent1 Years.Since.Graduation FY12Giving
## [1,100)      0.19920093 0.006747041 0.001977244
## [100,250)    0.23310801 0.006817701 0.001244376
## [250,500)    0.03969561 0.009941441 0.001673996
## [500,2e+05)  0.05520011 0.012588864 0.001660900
##           FY13Giving FY14Giving FY15Giving
## [1,100)      2.114204e-03 0.002407026 0.0017519877
## [100,250)    6.422508e-05 0.001212624 0.0008167613
## [250,500)    1.072025e-03 0.001476658 0.0008754247
## [500,2e+05)  1.013948e-03 0.001326860 0.0007187511
##
## Residual Deviance: 1531.13
## AIC: 2339.13
library(package = car)
Anova(mod.multinomial)

## Analysis of Deviance Table (Type II tests)
##
## Response: FY16GivingCat
##           LR Chisq Df Pr(>Chisq)
## X           11.809  4 0.0188295 *
## Marital.Status 24.680 12 0.0164131 *
## Major         179.231 176 0.4181470
## Next.Degree    182.533 184 0.5167178
## AttendanceEvent 30.462  4 3.940e-06 ***
## Years.Since.Graduation 21.213  4 0.0002874 ***
## FY12Giving     31.830  4 2.072e-06 ***
## FY13Giving     19.378  4 0.0006624 ***
## FY14Giving     20.568  4 0.0003856 ***
## FY15Giving     26.913  4 2.070e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

## Multinomial Simple

```
library(package = nnet)
```

```
mod.multinomial.simple <- multinom(data = df, formula = FY16GivingCat ~ X + Marital.Status + AttendanceEvent +
```

```
## # weights: 50 (36 variable)
## initial value 1609.437912
## iter 10 value 1112.654541
## iter 20 value 1039.745542
## iter 30 value 977.788300
## iter 40 value 974.641763
## iter 50 value 974.620966
## iter 60 value 974.612262
## iter 60 value 974.612254
## iter 60 value 974.612253
## final value 974.612253
## converged
```

```
summary(mod.multinomial.simple)
```

```
## Call:
```

```
## multinom(formula = FY16GivingCat ~ X + Marital.Status + AttendanceEvent +
##     Years.Since.Graduation + FY14Giving + FY15Giving, data = df)
```

```
##
```

```
## Coefficients:
```

```
## (Intercept) X Marital.StatusM Marital.StatusS
## [1,100) -1.094396 6.094023e-05 0.01301581 -0.3280017
## [100,250) -6.235589 2.789453e-03 0.39858624 -0.4698749
## [250,500) -9.442031 3.114156e-03 0.75090752 -0.3665107
## [500,2e+05) -1.182045 -3.939140e-03 0.19390909 0.1844194
## Marital.StatusW AttendanceEvent1 Years.Since.Graduation
## [1,100) 0.7214202 0.5251617 -0.01755943
## [100,250) -10.4337554 0.9515684 0.09459645
## [250,500) 1.9365695 1.8427502 0.11308730
## [500,2e+05) 2.0864838 1.5657635 -0.07609991
## FY14Giving FY15Giving
## [1,100) 0.0004961673 -0.0016517260
## [100,250) 0.0049161196 0.0006106346
## [250,500) 0.0042574307 0.0021006120
## [500,2e+05) 0.0053562669 0.0028846970
```

```
##
```

```
## Std. Errors:
```

```
## (Intercept) X Marital.StatusM Marital.StatusS
## [1,100) 0.15812474 0.0004516015 0.3405507 0.3702095
## [100,250) 0.06910706 0.0004465161 0.3647671 0.4318072
## [250,500) 0.03046050 0.0005954415 0.3409648 0.4469419
## [500,2e+05) 0.04961898 0.0006824100 0.3840737 0.4453429
## Marital.StatusW AttendanceEvent1 Years.Since.Graduation
## [1,100) 4.977846e-01 0.1836180 0.010897659
## [100,250) 3.879885e-06 0.2239752 0.009781095
## [250,500) 4.530880e-01 0.5006733 0.012820449
## [500,2e+05) 4.321122e-01 0.5084165 0.014383910
## FY14Giving FY15Giving
```

```
## [1,100)      0.001660934 0.0014495661
## [100,250)    0.001054706 0.0007116362
## [250,500)    0.001187905 0.0007257789
## [500,2e+05) 0.001095367 0.0006501918
##
## Residual Deviance: 1949.225
## AIC: 2021.225
Anova(mod.multinomial.simple)

## Analysis of Deviance Table (Type II tests)
##
## Response: FY16GivingCat
##              LR Chisq Df Pr(>Chisq)
## X              11.188  4  0.024530 *
## Marital.Status   25.842 12  0.011301 *
## AttendanceEvent  40.614  4  3.231e-08 ***
## Years.Since.Graduation 17.225  4  0.001748 **
## FY14Giving       35.403  4  3.838e-07 ***
## FY15Giving       32.888  4  1.259e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

## Ordinal Proportional

HERE plot CUMulativeLogitModelPlot from book page 171

```
library(package = ordinal)
```

```
## Warning: package 'ordinal' was built under R version 3.4.2
```

```
mod.ordinal = clm(data = df, formula = FY16GivingCat ~ X + Marital.Status + AttendanceEvent + Years.Sin
```

```
## Warning: (2) Model is nearly unidentifiable: very large eigenvalue
```

```
## - Rescale variables?
```

```
## In addition: Absolute and relative convergence criteria were met
```

```
summary(mod.ordinal)
```

```
## formula:
```

```
## FY16GivingCat ~ X + Marital.Status + AttendanceEvent + Years.Since.Graduation + FY14Giving + FY15Giv
```

```
## data:    df
```

```
##
```

```
## link threshold nobs logLik AIC      niter max.grad cond.H
```

```
## logit flexible 1000 -980.54 1985.07 8(0)  6.84e-12 4.2e+08
```

```
##
```

```
## Coefficients:
```

```
##              Estimate Std. Error z value Pr(>|z|)
```

```
## X              0.0012280  0.0007452   1.648   0.0994 .
```

```
## Marital.StatusM   0.3068771  0.2833023   1.083   0.2787
```

```
## Marital.StatusS  -0.1220790  0.3122376  -0.391   0.6958
```

```
## Marital.StatusW   0.7863203  0.6903797   1.139   0.2547
```

```
## AttendanceEvent1  0.7981985  0.1425167   5.601 2.13e-08 ***
```

```
## Years.Since.Graduation 0.0399573  0.0197457   2.024   0.0430 *
```

```
## FY14Giving        0.0044811  0.0007507   5.969 2.39e-09 ***
```

```
## FY15Giving        0.0032961  0.0005826   5.657 1.54e-08 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##               Estimate Std. Error z value
## [0,1)|[1,100)      2.9714      0.9208  3.227
## [1,100)|[100,250)   4.0450      0.9260  4.368
## [100,250)|[250,500) 5.7972      0.9430  6.148
## [250,500)|[500,2e+05) 6.9663      0.9600  7.257

library(package = ordinal)
mod.ordinal = clm(data = df, formula = FY16GivingCat ~ X + AttendanceEvent + Years.Since.Graduation + FY14Giving + FY15Giving)

## Warning: (2) Model is nearly unidentifiable: very large eigenvalue
## - Rescale variables?
## In addition: Absolute and relative convergence criteria were met

summary(mod.ordinal)

## formula:
## FY16GivingCat ~ X + AttendanceEvent + Years.Since.Graduation + FY14Giving + FY15Giving
## data:      df
##
## link threshold nobs logLik AIC      niter max.grad cond.H
## logit flexible 1000 -984.94 1987.89 8(0) 1.28e-11 3.6e+08
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## X               0.0010276  0.0007345   1.399   0.1618
## AttendanceEvent1  0.8180833  0.1420709   5.758 8.50e-09 ***
## Years.Since.Graduation 0.0399222  0.0194682   2.051   0.0403 *
## FY14Giving        0.0045810  0.0007605   6.023 1.71e-09 ***
## FY15Giving        0.0033825  0.0005834   5.798 6.70e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##               Estimate Std. Error z value
## [0,1)|[1,100)      2.7180      0.8573  3.171
## [1,100)|[100,250)   3.7839      0.8623  4.388
## [100,250)|[250,500) 5.5303      0.8793  6.290
## [250,500)|[500,2e+05) 6.7075      0.8976  7.473
```

## Ordinal Non-Proportional

**Section 1: Introduction**

**Section 2: EDA**

**Section 3: Statistical Modeling**

**Section 4: Final Remarks**