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 (AttendenceEvent), 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$AttendenceEvent = factor(df$AttendenceEvent)
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 ...
##  $ AttendenceEvent      : 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
##   AttendenceEvent 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
```

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
```

AttendenceEvent Variable

```
describe(df$AttendenceEvent)
```

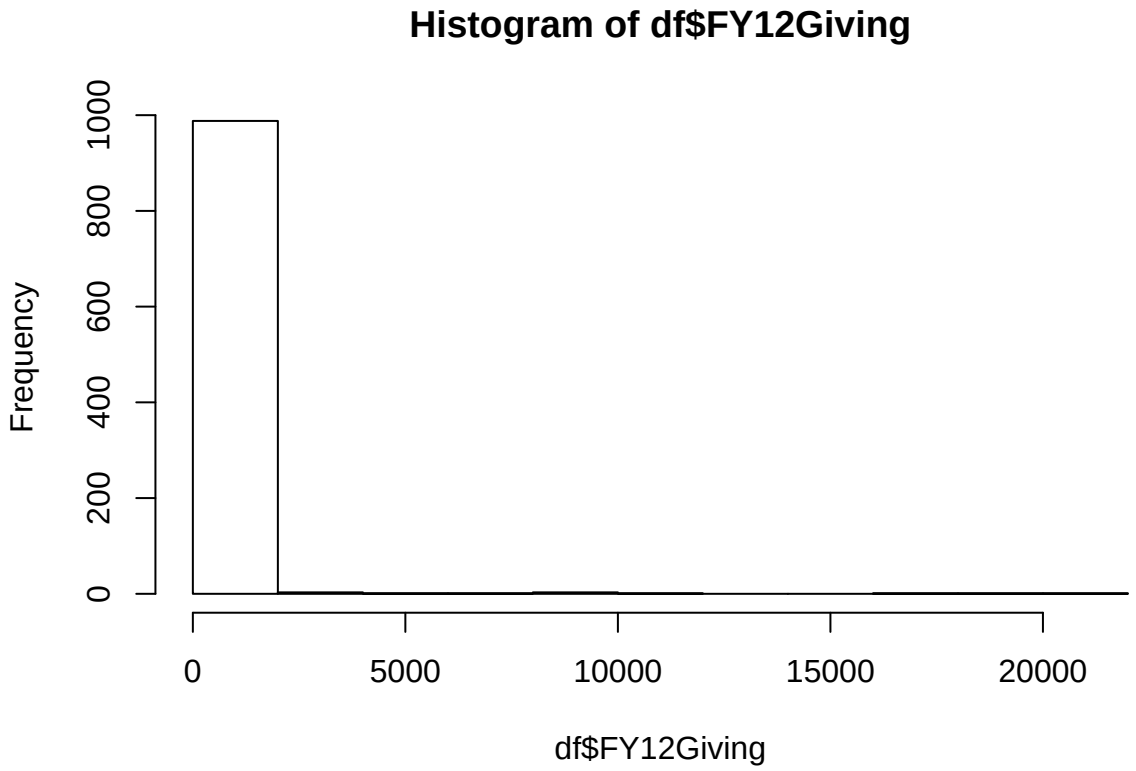
```
## df$AttendenceEvent
##        n  missing distinct
##     1000        0        2
##
## Value          0     1
## Frequency    395   605
## Proportion 0.395 0.605
```

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)
```



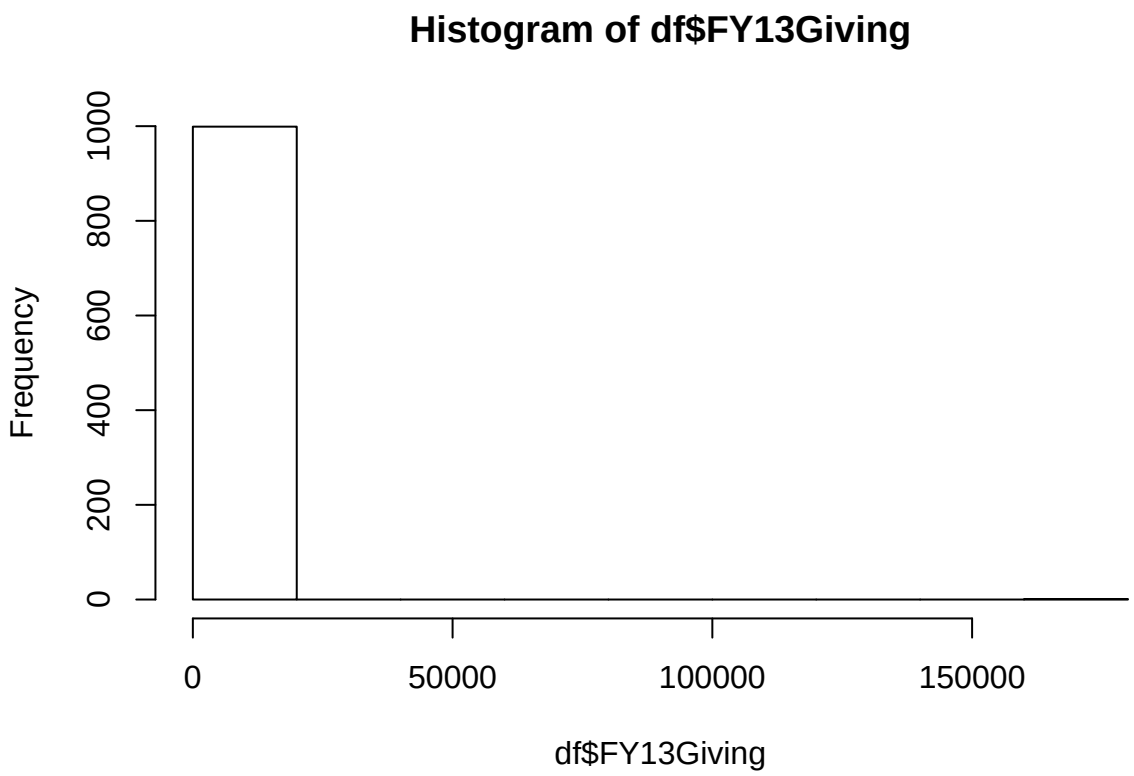
FY13Giving Variable

```
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)
```

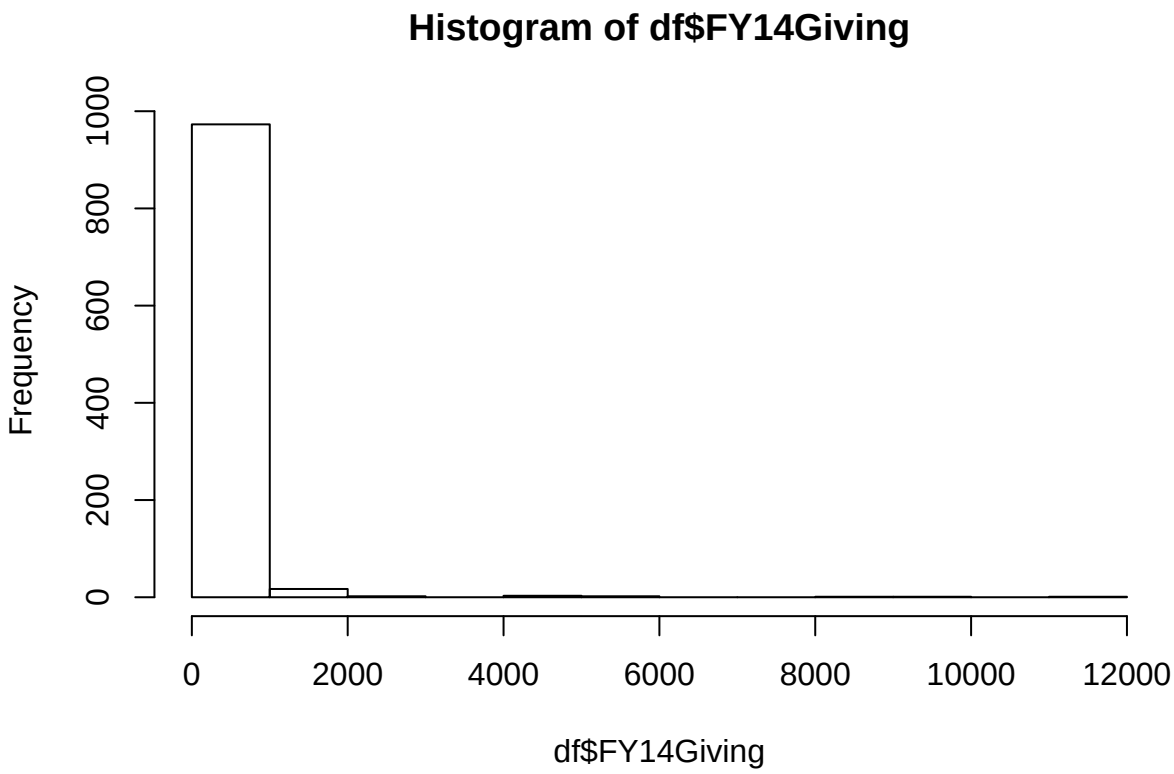


FY14Giving Variable

```
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)
```

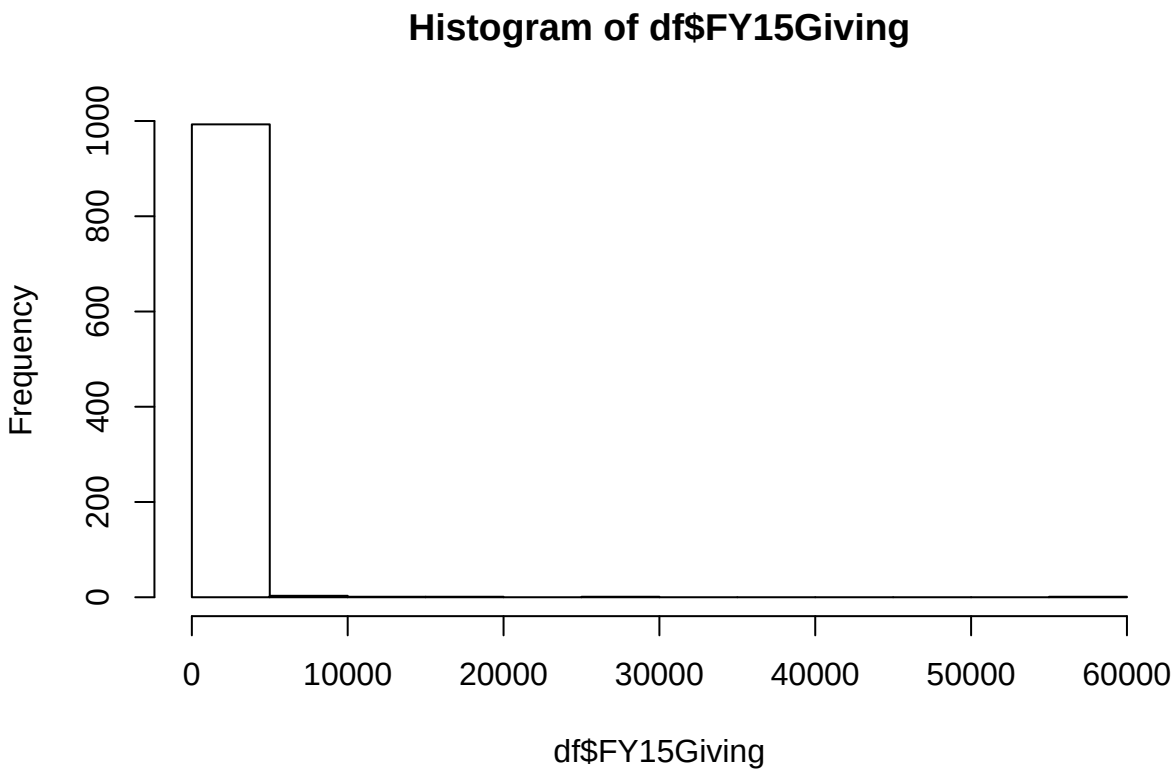


FY15Giving Variable

```
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)
```

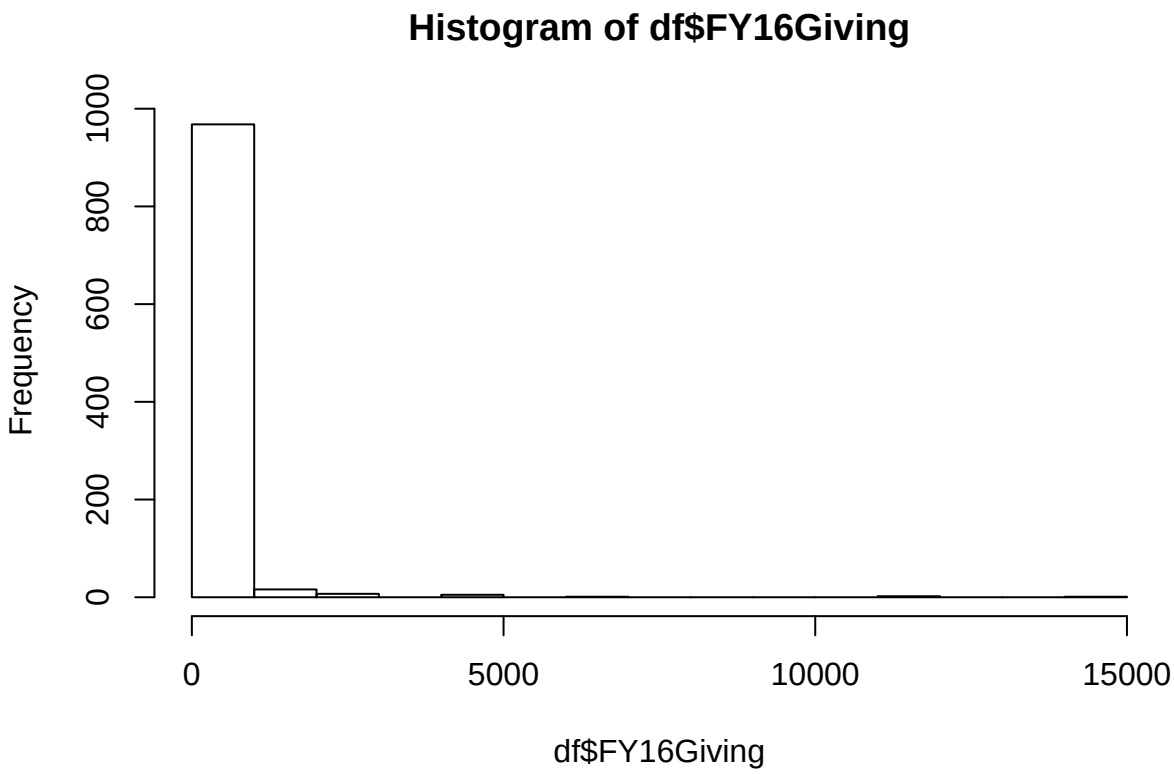


FY16Giving Variable

```
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)
```



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
## ---------------------------------------------------------------------------
## AttendenceEvent
##        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
## ---------------------------------------------------------------------------
```

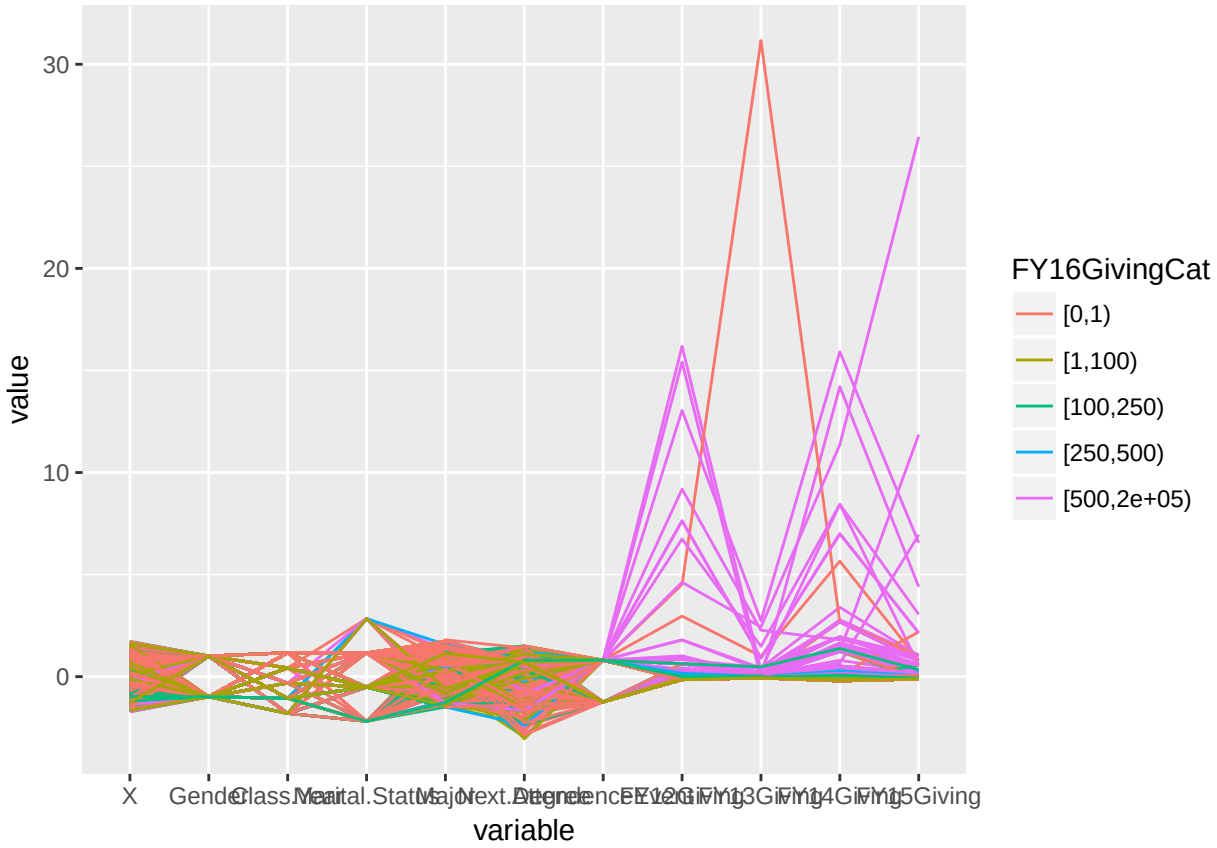
```
## FY16GivingCat
##        n  missing distinct
##     1000        0        5
##
## Value            [0,1)     [1,100)   [100,250)   [250,500) [500,2e+05)
## Frequency          586         173         143          39          59
## Proportion       0.586       0.173       0.143       0.039       0.059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

Parallel Coordinate

```
library(GGally)
```

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

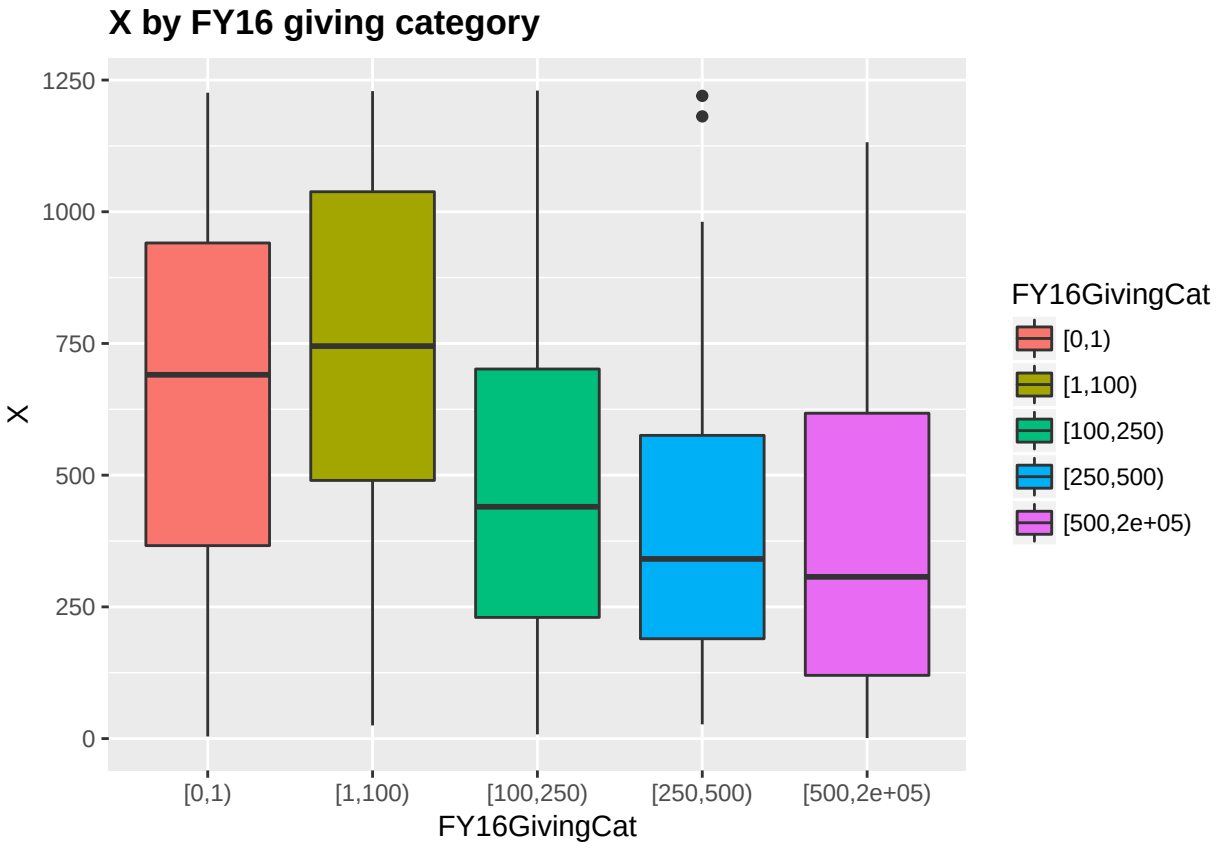
```
ggparcoord(df, columns = 1:(ncol(df) - 3), groupColumn = 14, scale = "std", scaleSummary = "mean")
```




```
#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 = "")
```

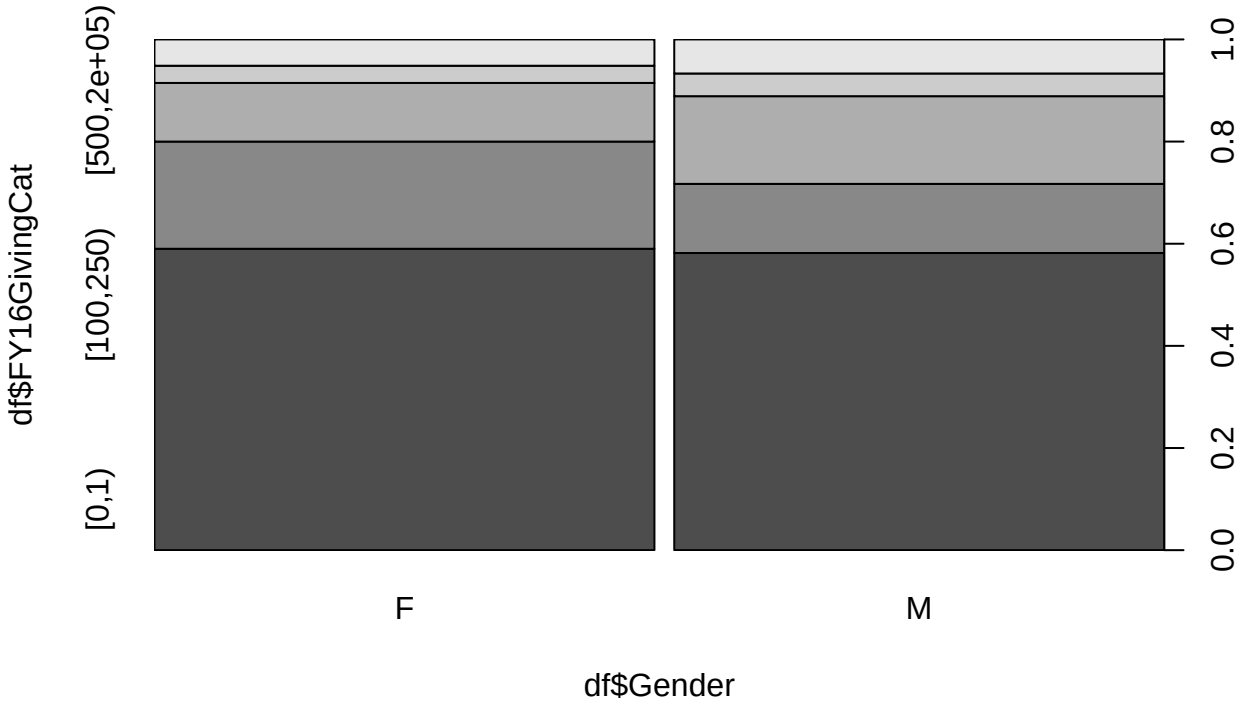
X Variable

```
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"))
```



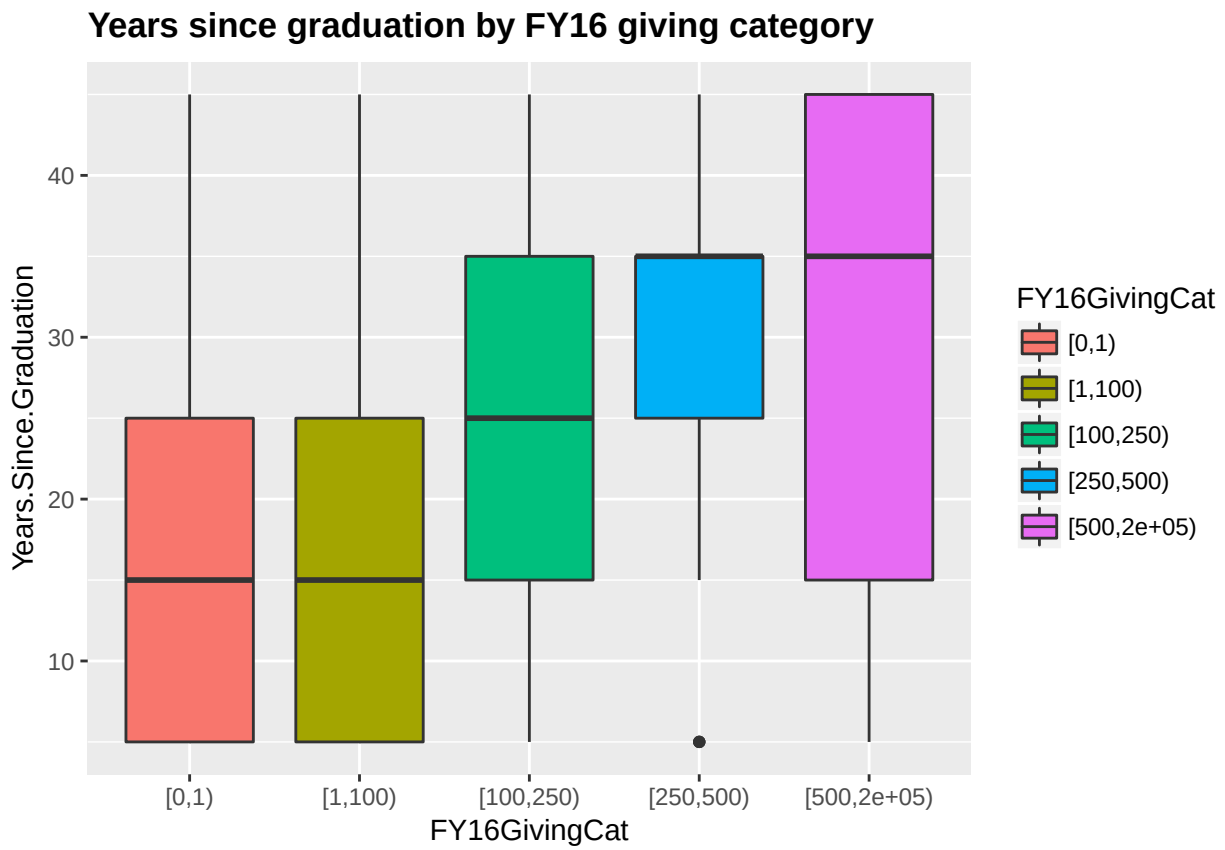
Gender Variable

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



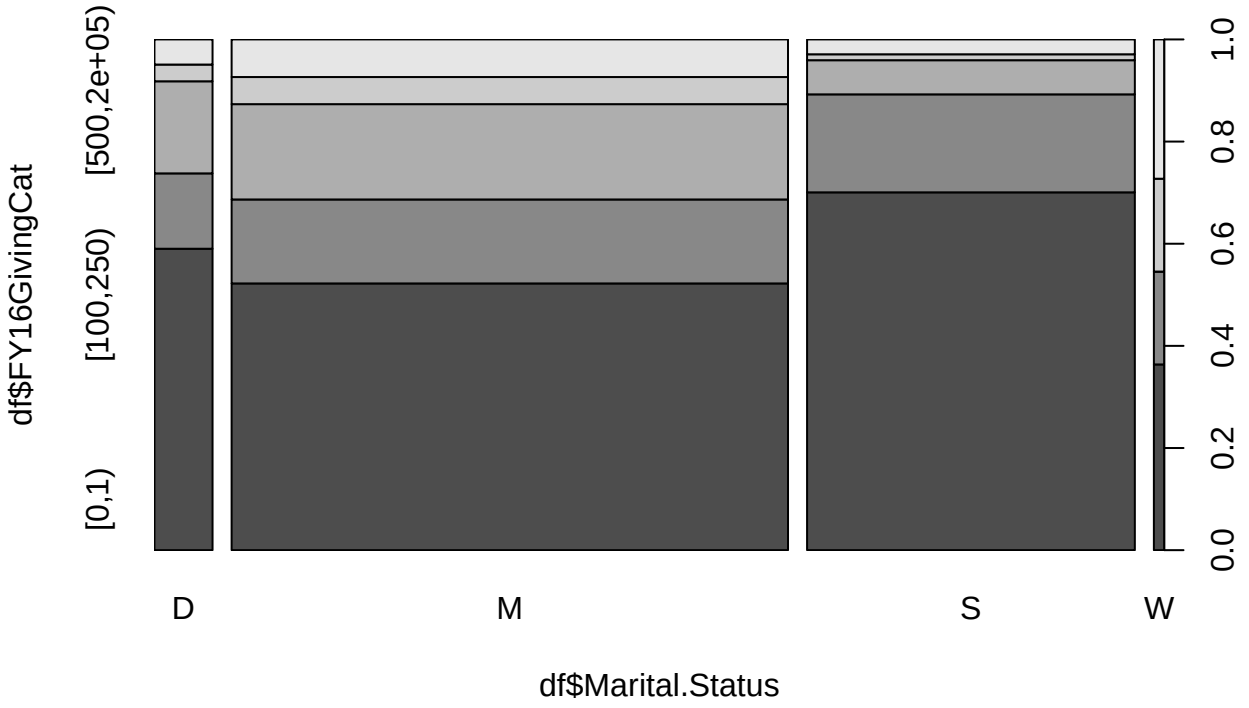
Years.Since.Graduation Variable

```
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"))
```



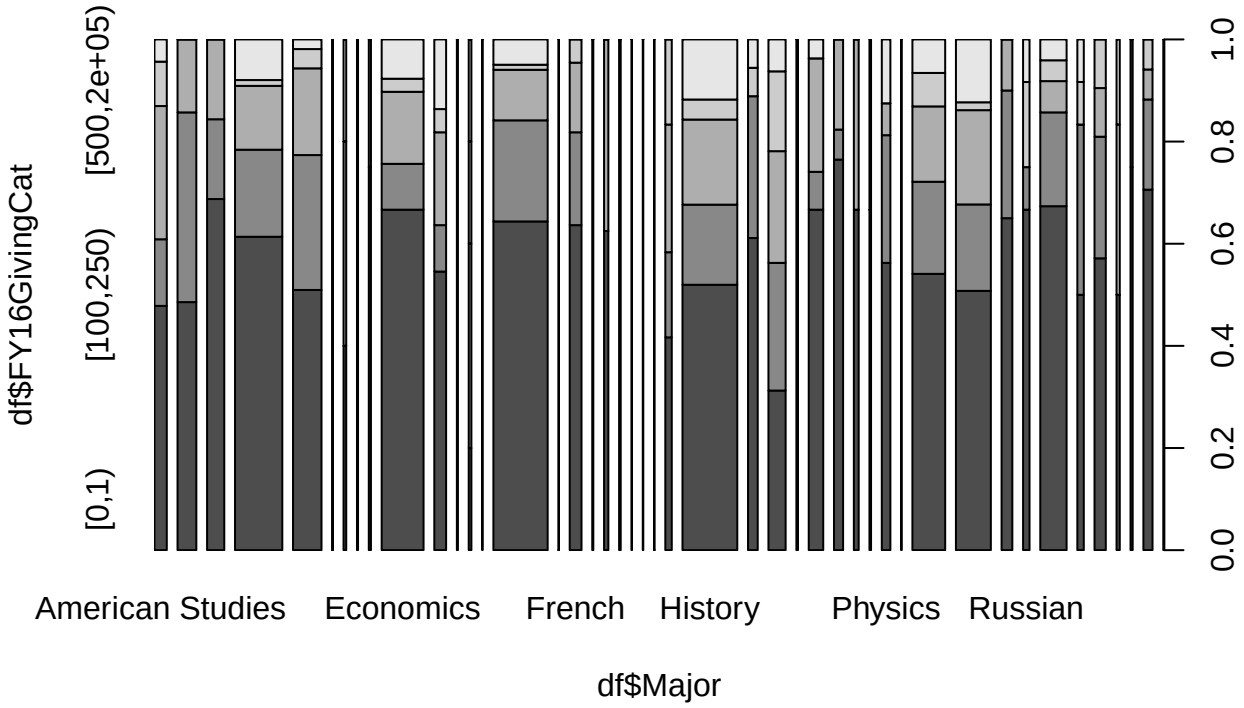
Marital.Status Variable

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



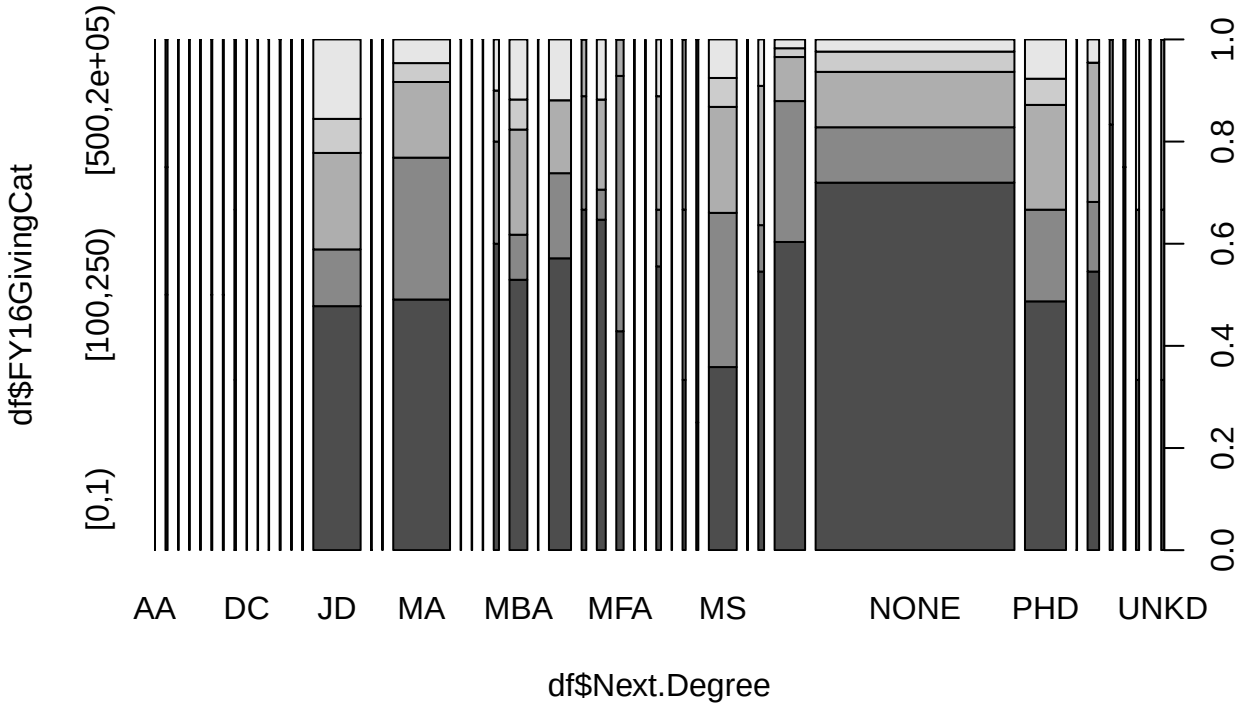
Major Variable

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



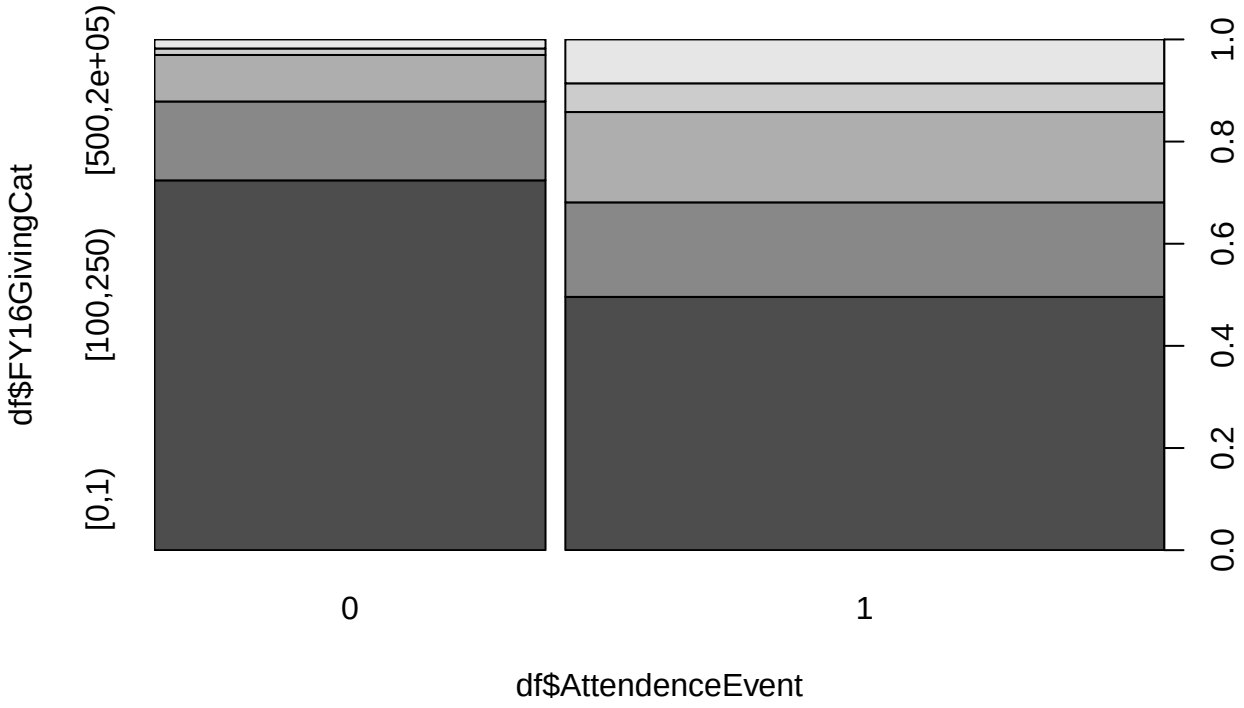
Next.Degree Variable

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



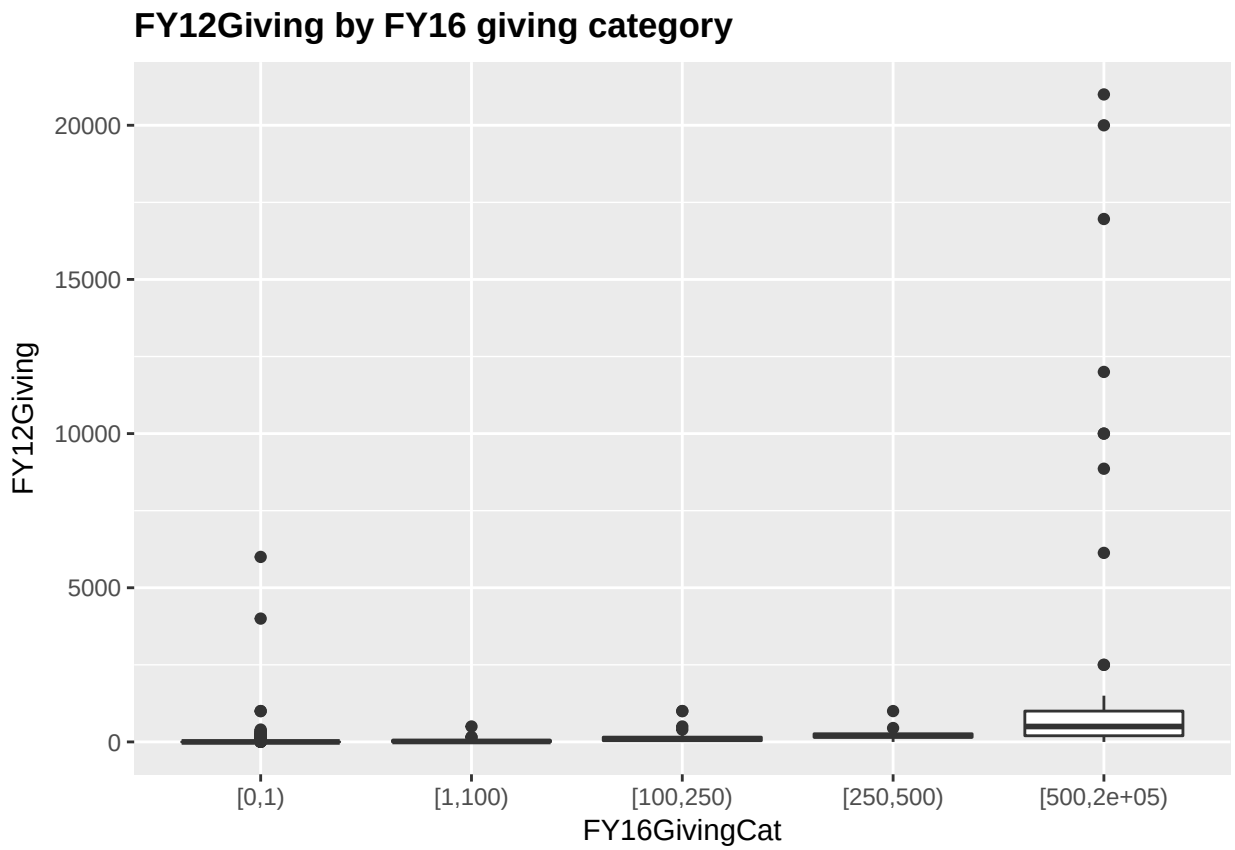
AttendenceEvent Variable

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



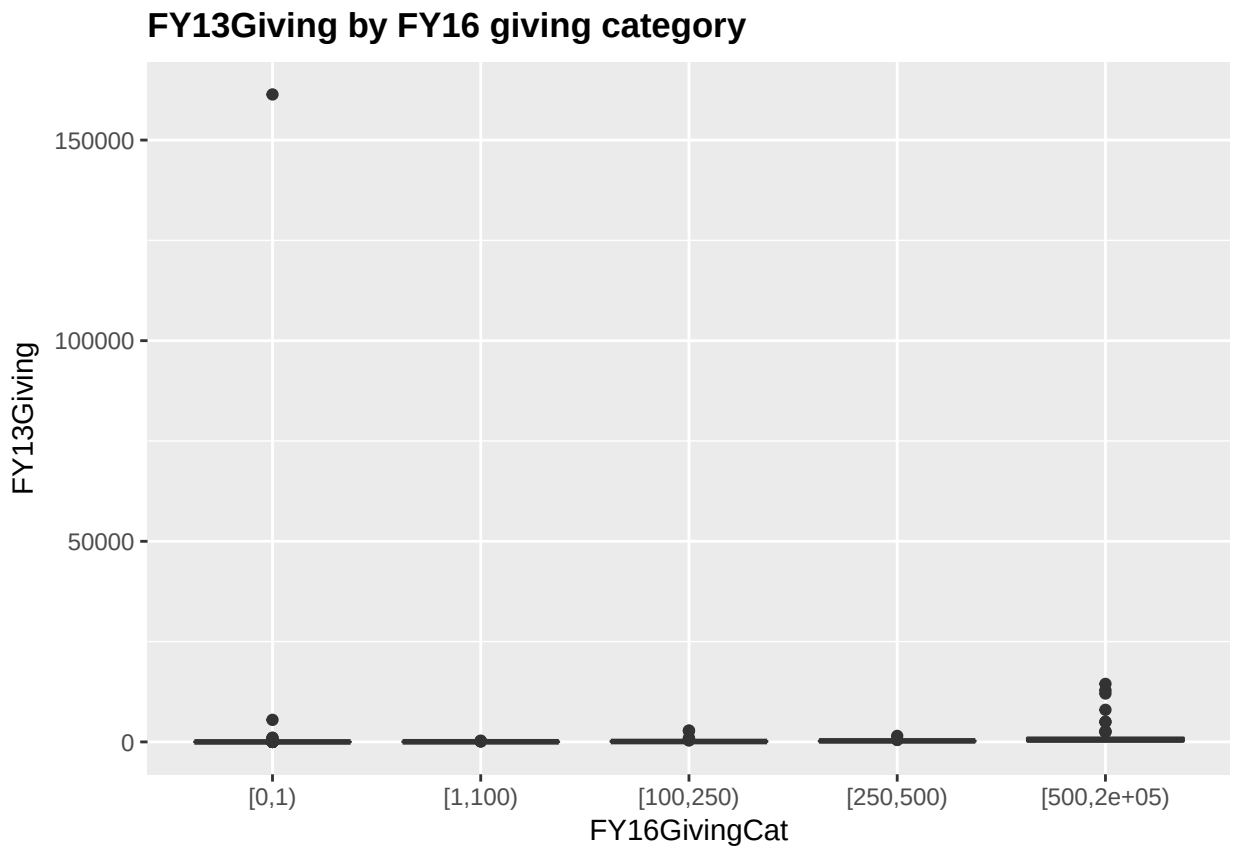
FY12Giving Variable

```
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"))
```



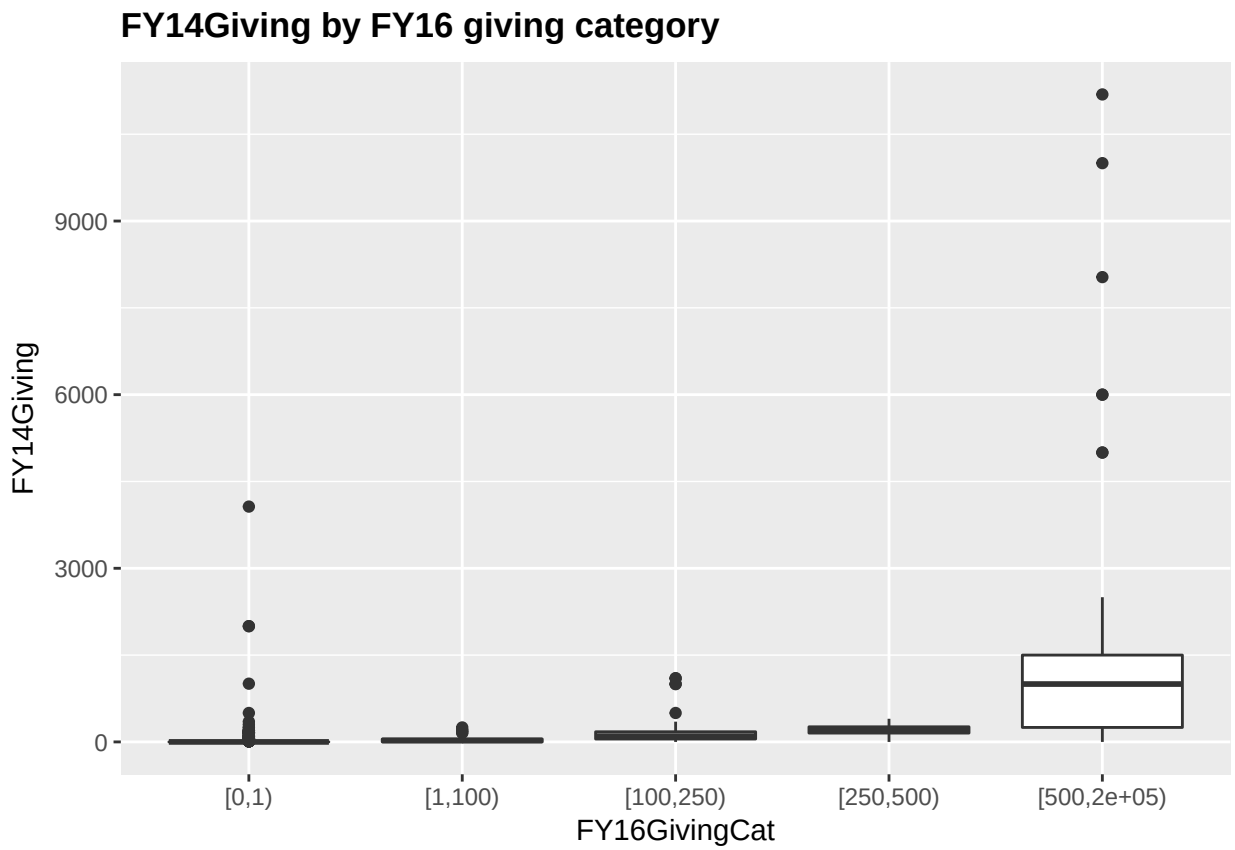
FY13Giving Variable

```
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"))
```



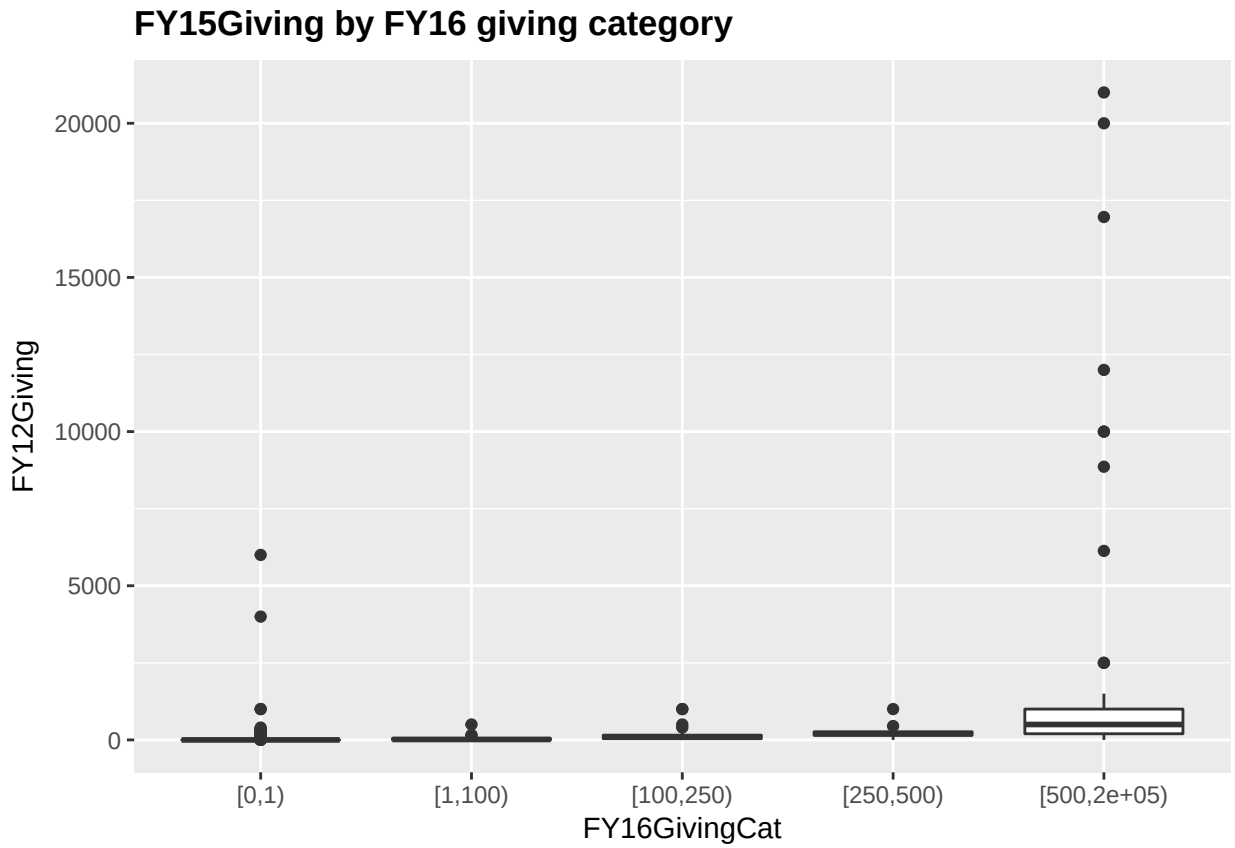
FY14Giving Variable

```
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  AttendenceEvent   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 ~ Marital.Status + Major + Next.Degree +
```

```
## # weights:  505 (400 variable)
## initial  value 1609.437912
## iter  10 value 1506.932450
## iter  20 value 1384.223066
## iter  30 value 930.664605
## iter  40 value 812.872805
## iter  50 value 786.482871
## iter  60 value 778.126775
## iter  70 value 774.929839
## iter  80 value 772.725820
## iter  90 value 771.799322
## iter 100 value 771.469307
## final  value 771.469307
## stopped after 100 iterations
```

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

```
## Call:
## multinom(formula = FY16GivingCat ~ Marital.Status + Major + Next.Degree +
##     AttendenceEvent + Years.Since.Graduation + FY12Giving + FY13Giving +
##     FY14Giving + FY15Giving, data = df)
##
## Coefficients:
##             (Intercept) Marital.StatusM Marital.StatusS Marital.StatusW
## [1,100)        2.327450      0.04611111     -0.21520635       0.9603192
## [100,250)     -5.488694      0.55963714     -0.03598911      -7.6186376
## [250,500)    -11.033203      1.53412497     -0.12289885       4.4746398
## [500,2e+05)   -6.519307     -0.74845721     -0.73715352       3.1047009
##             MajorAnthropology   MajorArt MajorBiology MajorChemistry
## [1,100)            1.29216859 -0.4471864   -0.2012643     0.61627992
## [100,250)         -0.04943187 -0.2067274   -1.0067984    -0.31998663
## [250,500)         -5.66802472 -8.3094057   -1.7977902    -0.00515456
## [500,2e+05)       -6.37789650 -8.0600881   -1.2468001    -3.20668324
##             MajorChinese MajorClassics MajorComparative Literature
## [1,100)     -1.399638515     -4.758323                   -3.907482
```

```
## [100,250)   13.491339615      1.229843                   -7.331690
## [250,500)   -0.052003658     -3.019845                   -5.050414
## [500,2e+05) -0.006010933      2.718885                   -1.559036
##             MajorComputer Science MajorEconomics MajorEconomics-Business
## [1,100)                 -5.168570     -0.8172153               0.7824203
## [100,250)               -1.658805     -0.8463937              -0.9959211
## [250,500)               -3.692374     -1.4342109              -1.2871874
## [500,2e+05)             -2.104285     -1.5642899               0.1571299
##             MajorEconomics-Regional Stds. MajorEducation MajorEngineering
## [1,100)                        -6.257238      3.2124926       -5.6573340
## [100,250)                      -9.358436     -0.8968721       -4.3083256
## [250,500)                      -5.727310     -0.9129813       -0.3683641
## [500,2e+05)                    -3.953035     -4.4972169       -1.1269127
##             MajorEnglish MajorEnglish-Journalism MajorFrench
## [1,100)         0.263610             -0.01725597  -0.1039798
## [100,250)      -1.192876              8.23399400  -0.9664248
## [250,500)      -2.199621             -3.21714009  -0.6459561
## [500,2e+05)    -1.200338             -1.27713853  -6.6912685
##             MajorGeneral Science MajorGeneral Science-Biology
## [1,100)                -4.163248                 -8.657947696
## [100,250)              -8.344227                 -0.007755967
## [250,500)              -1.272340                 -9.889013577
## [500,2e+05)            -4.145628                 -3.565849262
##             MajorGeneral Science-Chemistry MajorGeneral Science-Math
## [1,100)                         -6.255626                -3.5808921
## [100,250)                       -5.695960                -3.1631127
## [250,500)                       -1.495498                -0.1107222
## [500,2e+05)                     -2.162928                -0.1565820
##             MajorGeneral Science-Physics MajorGeneral Science-Psycho
## [1,100)                      -4.2346653                 -1.2585590
## [100,250)                    -3.4236773                  9.3856793
## [250,500)                    -0.4509732                 -0.1389697
## [500,2e+05)                  -0.2096891                 -0.4576594
##             MajorGerman MajorHistory MajorIndependent MajorMathematics
## [1,100)       0.6536842    0.2042419        0.1128993        1.0842570
## [100,250)     0.4848910   -0.7093639       -8.4598959        0.3035737
## [250,500)     3.2829183   -1.2620322        0.2440909        1.8087815
## [500,2e+05)  -2.8709063   -2.1739280       -1.5181561        0.3985312
##             MajorMathematics-Physics MajorMusic MajorPhilosophy
## [1,100)                   -4.670706 -1.0811228      -1.2607062
## [100,250)                -10.448173 -0.6607272      -0.4448458
## [250,500)                 -2.231392 -6.9239047      -6.5038972
## [500,2e+05)               -2.112867 -9.6693453      -6.3818130
##             MajorPhilosophy-Religion MajorPhysical Education MajorPhysics
## [1,100)                     -7.270036              -4.8340164    0.3639836
## [100,250)                   -1.331899              -7.0804607   -1.3279140
## [250,500)                   -7.071706               0.5247904   -5.5163938
## [500,2e+05)                 -5.641239             -11.5866213   -1.7466712
##             MajorPol. Sci.-Regional Stds. MajorPolitical Science
## [1,100)                       -2.38518403            0.402650513
## [100,250)                     -6.75601996           -0.710099976
## [250,500)                     -0.06302349            0.007005596
## [500,2e+05)                   -2.59707374           -1.776503767
##             MajorPsychology MajorReligious Studies MajorRussian
```

```
## [1,100)           0.2184010              0.4752823  -1.44881884
## [100,250)        -0.5615642             -0.9221519  -8.44509673
## [250,500)        -1.0776067             -6.6489101   0.97159750
## [500,2e+05)       0.5961466             -6.3088953   0.04864469
##             MajorSociology MajorSociology-Anthropology MajorSpanish
## [1,100)          0.2760973                   1.4699983    0.7086929
## [100,250)       -1.2495037                  -8.7002793   -0.6638570
## [250,500)        0.1743947                   0.4106949    1.4680470
## [500,2e+05)     -6.4678982                  -1.1739715   -4.9785746
##             MajorSpeech (Drama, etc.) MajorSpeech Correction MajorTheatre
## [1,100)                    -5.2605198               1.623150   -0.5867579
## [100,250)                  -8.0096618              -7.088090   -2.2905143
## [250,500)                   0.8187301              -3.428523    1.7062939
## [500,2e+05)                -5.3742356              -1.816381   -5.3010538
##             MajorZoology Next.DegreeBA Next.DegreeBAE Next.DegreeBD
## [1,100)       -4.091781     -2.749904    -6.22788022    -6.4378254
## [100,250)     -3.297186     -5.562335    -1.82682358    -3.6124347
## [250,500)     -1.138464      4.133532     0.05196747    -0.6950866
## [500,2e+05)   -1.643129     -4.050388    -0.05729107    -0.8164214
##             Next.DegreeBFA Next.DegreeBN Next.DegreeBS Next.DegreeBSN
## [1,100)          -7.407278     -8.250654     -4.149833      6.9712601
## [100,250)        -2.558556      4.094416     -2.493170      8.3641609
## [250,500)        -0.180456     -1.933376     -5.716619     16.5561713
## [500,2e+05)      -3.640551     -2.644002      9.358349     -0.8317175
##             Next.DegreeDC Next.DegreeDDS Next.DegreeDMD Next.DegreeDO
## [1,100)       -7.14018949     8.05911631      9.5403623    -8.1035309
## [100,250)     -1.50553856    -0.80848192     -0.3689505    -3.9140074
## [250,500)      0.06203453     0.05314537     -0.6697333    -0.8052708
## [500,2e+05)   -1.71703496    -0.34549728     -0.6970407    -2.7426464
##             Next.DegreeDO2 Next.DegreeDP Next.DegreeJD Next.DegreeLLB
## [1,100)         -2.8046065    8.08777959     -3.548747      0.2776344
## [100,250)       -1.6337924   -0.70454960      2.807358     -2.8363453
## [250,500)       -0.5288342    0.03873708      4.338319     -8.8652651
## [500,2e+05)     -1.1163558   -0.23733111      3.724342      7.6786758
##             Next.DegreeLLD Next.DegreeMA Next.DegreeMA2 Next.DegreeMAE
## [1,100)         -7.2992762     -2.503275     -6.9657719     -9.6469664
## [100,250)       -3.0289143      2.676167     -4.0452459     -4.3565102
## [250,500)       -0.5367356      3.918078     -0.1558050     -0.3142169
## [500,2e+05)     -1.8487962      2.630070     -0.3753577     -0.4194529
##             Next.DegreeMALS Next.DegreeMAT Next.DegreeMBA Next.DegreeMCP
## [1,100)          10.0791616     -2.4289500      -3.772867     6.87968064
## [100,250)        -2.2277769      0.9657316       3.081588    -2.34218976
## [250,500)        -0.6178047     -5.5485979       3.589914    -0.09609383
## [500,2e+05)      -1.3264595      4.0221502       1.538359    -0.06663494
##             Next.DegreeMD Next.DegreeMD2 Next.DegreeME Next.DegreeMFA
## [1,100)         -3.216524      -2.997409     -4.769111      -1.561326
## [100,250)        2.624514       2.178897      3.228510       3.019682
## [250,500)       -4.316620      -2.115678     -6.995822      -5.043119
## [500,2e+05)      3.328515      -4.713648      2.749881      -4.755116
##             Next.DegreeMHA Next.DegreeML Next.DegreeMLS Next.DegreeMM
## [1,100)          -2.429740     0.2927016      -3.879948    -5.6438603
## [100,250)        -1.513143    -0.7984690       2.746995    -2.8997360
## [250,500)        17.258194    -2.2912866      -3.526293    -0.2948993
## [500,2e+05)      -1.062967     2.0192228       2.723423    -0.7738558
```

```
##             Next.DegreeMPA Next.DegreeMPH Next.DegreeMS Next.DegreeMSM
## [1,100)          -2.016226     -0.4214465     -2.106870     8.20157746
## [100,250)         3.499982     -2.8656754      3.184617    -0.59429010
## [250,500)        -2.816222     -3.0918286      3.471930     0.07508463
## [500,2e+05)      -3.545694     -2.4832313      2.883775    -0.74243995
##             Next.DegreeMSW Next.DegreeNDA Next.DegreeNONE Next.DegreePHD
## [1,100)          -4.035922      -3.130458       -4.023511      -2.977576
## [100,250)         3.171659       2.891045        2.295806       2.665881
## [250,500)        -3.661218       3.812912        3.247152       3.372851
## [500,2e+05)      -1.419212       2.904915        1.459877       1.974012
##             Next.DegreeSTM Next.DegreeTC Next.DegreeUBDS Next.DegreeUDDS
## [1,100)         -0.3286074     -3.775554       -3.641395       -8.460115
## [100,250)       12.0403512      2.361088       -6.696314       -6.062074
## [250,500)       -0.1593414     -8.537502       -5.847374        5.691306
## [500,2e+05)     -0.2993226     -5.825148       -3.260822       -3.889230
##             Next.DegreeUMD Next.DegreeUMDS Next.DegreeUNKD
## [1,100)          -1.066710       -6.856614      -1.7851392
## [100,250)        -4.584531       -3.981674       4.1732671
## [250,500)        -1.027578       -1.877904      -0.6216946
## [500,2e+05)       5.486059       -1.033654      -3.5148267
##             AttendenceEvent1 Years.Since.Graduation  FY12Giving
## [1,100)            0.2567138            -0.02651590 0.001969547
## [100,250)          1.0001187             0.03781338 0.001537147
## [250,500)          2.2632863             0.06047592 0.007211715
## [500,2e+05)        1.8841415             0.01224883 0.009419805
##                FY13Giving  FY14Giving    FY15Giving
## [1,100)     -0.0037215536 0.002067283 -0.0014102458
## [100,250)   -0.0000812538 0.005447252 -0.0002024156
## [250,500)   -0.0021021191 0.004278098  0.0013787135
## [500,2e+05) -0.0041394942 0.005294580  0.0024932523
##
## Std. Errors:
##             (Intercept) Marital.StatusM Marital.StatusS Marital.StatusW
## [1,100)       0.1175661       0.1400243     0.123000597    1.660205e-02
## [100,250)     0.1568921       0.1659424     0.164286243    7.831318e-06
## [250,500)     0.1274182       0.1574534     0.007515569    1.309020e-02
## [500,2e+05)   0.1564805       0.0890573     0.097042073    5.049879e-03
##             MajorAnthropology     MajorArt MajorBiology MajorChemistry
## [1,100)          7.538149e-02 1.938233e-02  0.253177724    0.250393447
## [100,250)        2.953549e-02 2.536043e-02  0.162549262    0.142372881
## [250,500)        3.115637e-05 1.833034e-05  0.004616655    0.013828304
## [500,2e+05)      4.659540e-05 5.900984e-06  0.036617919    0.003562964
##             MajorChinese MajorClassics MajorComparative Literature
## [1,100)     1.054328e-08  1.591404e-05                2.908232e-05
## [100,250)   2.870685e-07  9.469335e-03                1.012731e-05
## [250,500)   1.274004e-09  4.121711e-05                1.526921e-05
## [500,2e+05) 1.532178e-09  1.360491e-02                1.227374e-04
##             MajorComputer Science MajorEconomics MajorEconomics-Business
## [1,100)              1.519579e-05     0.08557284              0.015464236
## [100,250)            1.369471e-03     0.25967170              0.033111683
## [250,500)            4.581784e-05     0.01832705              0.007672979
## [500,2e+05)          2.225916e-04     0.02768107              0.014458181
##             MajorEconomics-Regional Stds. MajorEducation MajorEngineering
## [1,100)                     2.311450e-05   0.0166986243     3.909127e-05
```

```
## [100,250)                   5.077410e-06   0.0090552271     7.020985e-05
## [250,500)                   1.829154e-05   0.0126264831     1.180542e-05
## [500,2e+05)                 9.635745e-05   0.0001726704     6.728903e-05
##             MajorEnglish MajorEnglish-Journalism  MajorFrench
## [1,100)       0.25527251           5.563638e-08 1.947498e-02
## [100,250)     0.21556613           7.346719e-06 1.308325e-02
## [250,500)     0.01084929           6.033081e-07 6.684904e-03
## [500,2e+05)   0.03104487           3.049853e-06 2.311924e-05
##             MajorGeneral Science MajorGeneral Science-Biology
## [1,100)             1.308118e-05                 5.479084e-05
## [100,250)           4.920979e-06                 1.064881e-02
## [250,500)           2.243025e-05                 8.974026e-05
## [500,2e+05)         7.992687e-05                 1.380709e-04
##             MajorGeneral Science-Chemistry MajorGeneral Science-Math
## [1,100)                      1.995857e-05              2.131189e-05
## [100,250)                    1.936796e-05              5.196421e-05
## [250,500)                    6.029557e-05              7.184625e-06
## [500,2e+05)                  2.598803e-04              2.596700e-05
##             MajorGeneral Science-Physics MajorGeneral Science-Psycho
## [1,100)                     2.437799e-05                5.644672e-08
## [100,250)                   5.481631e-05                6.773738e-07
## [250,500)                   4.201922e-05                2.478635e-12
## [500,2e+05)                 4.194670e-05                2.108132e-10
##              MajorGerman MajorHistory MajorIndependent MajorMathematics
## [1,100)     0.0070181607   0.27402398     1.807319e-02       0.11641740
## [100,250)   0.0137889224   0.27437166     4.419127e-06       0.10633155
## [250,500)   0.0133174376   0.03067016     7.732406e-03       0.04359465
## [500,2e+05) 0.0001269319   0.02721804     6.563118e-03       0.01663717
##             MajorMathematics-Physics   MajorMusic MajorPhilosophy
## [1,100)                5.118029e-05 7.678448e-03    8.808303e-03
## [100,250)              3.471475e-05 2.031225e-02    2.702581e-02
## [250,500)              1.011667e-04 4.303203e-05    4.154954e-05
## [500,2e+05)            6.901363e-05 3.475112e-06    5.114226e-05
##             MajorPhilosophy-Religion MajorPhysical Education MajorPhysics
## [1,100)                7.043402e-06            3.448025e-05 0.0210858662
## [100,250)              1.077684e-02            9.666308e-06 0.0071399778
## [250,500)              1.151482e-05            2.368606e-03 0.0000209228
## [500,2e+05)            4.990798e-05            2.262401e-04 0.0039924645
##             MajorPol. Sci.-Regional Stds. MajorPolitical Science
## [1,100)                      3.164398e-05             0.21243405
## [100,250)                    1.543210e-05             0.15976279
## [250,500)                    1.094749e-08             0.06534643
## [500,2e+05)                  5.515680e-05             0.01411794
##             MajorPsychology MajorReligious Studies MajorRussian
## [1,100)         0.169326589           1.537156e-02 3.806281e-03
## [100,250)       0.263421969           8.688199e-03 7.472344e-06
## [250,500)       0.008137099           2.913277e-05 2.143468e-02
## [500,2e+05)     0.069001796           6.940683e-05 1.484975e-02
##             MajorSociology MajorSociology-Anthropology MajorSpanish
## [1,100)       4.041289e-02                0.0182845960 2.795522e-02
## [100,250)     1.050454e-02                0.0000059231 1.069100e-02
## [250,500)     6.029216e-03                0.0096889997 9.149927e-03
## [500,2e+05)   5.946066e-05                0.0040318019 4.126176e-05
##             MajorSpeech (Drama, etc.) MajorSpeech Correction MajorTheatre
```

```
## [1,100)                 3.440147e-05           7.473181e-03 0.0116590969
## [100,250)               1.197684e-05           7.979797e-06 0.0044608183
## [250,500)               2.374246e-03           3.606969e-05 0.0061095728
## [500,2e+05)             3.084087e-05           1.129254e-04 0.0000962814
##             MajorZoology Next.DegreeBA Next.DegreeBAE Next.DegreeBD
## [1,100)     2.795444e-05  7.299735e-03   6.779633e-05  1.703384e-04
## [100,250)   1.609292e-06  3.771137e-06   1.337088e-05  1.519800e-05
## [250,500)   3.480307e-06  9.613133e-04   1.911384e-09  4.472028e-06
## [500,2e+05) 1.267202e-05  1.137829e-06   6.579820e-10  2.515177e-06
##             Next.DegreeBFA Next.DegreeBN Next.DegreeBS Next.DegreeBSN
## [1,100)       9.542233e-05  7.309820e-05  2.516943e-05   1.328470e-04
## [100,250)     2.591712e-05  8.848071e-03  8.215648e-07   1.851854e-04
## [250,500)     7.789063e-07  6.747541e-06  4.056506e-06   1.104304e-04
## [500,2e+05)   6.670821e-06  1.378613e-05  9.032972e-05   6.183218e-09
##             Next.DegreeDC Next.DegreeDDS Next.DegreeDMD Next.DegreeDO
## [1,100)      1.056201e-04   7.405286e-07   9.420258e-08  9.898265e-05
## [100,250)    3.428112e-05   5.329033e-09   1.146099e-12  8.167314e-06
## [250,500)    7.711716e-08   2.580812e-10   1.258449e-10  3.203833e-06
## [500,2e+05)  4.021286e-06   1.797297e-09   4.326077e-10  5.265792e-06
##             Next.DegreeDO2 Next.DegreeDP Next.DegreeJD Next.DegreeLLB
## [1,100)       2.769300e-05  7.711566e-07    0.23342750   1.705685e-17
## [100,250)     1.485788e-06  4.641079e-09    0.22229872   5.817247e-27
## [250,500)     2.325734e-06  1.979105e-10    0.08348505   4.106455e-11
## [500,2e+05)   1.013508e-05  1.432531e-09    0.07511524   4.106455e-11
##             Next.DegreeLLD Next.DegreeMA Next.DegreeMA2 Next.DegreeMAE
## [1,100)       3.650069e-05    0.22791075   3.511041e-05   2.387223e-05
## [100,250)     6.027876e-06    0.23692709   3.161657e-06   3.227189e-06
## [250,500)     4.681720e-06    0.02987273   7.964684e-09   1.034205e-07
## [500,2e+05)   8.962309e-06    0.03999956   2.422994e-08   1.392957e-07
##             Next.DegreeMALS Next.DegreeMAT Next.DegreeMBA Next.DegreeMCP
## [1,100)        2.247399e-07   1.125847e-02    0.024848459   4.296727e-07
## [100,250)      1.906875e-09   1.012812e-02    0.116929179   6.378959e-09
## [250,500)      2.124326e-10   7.768088e-07    0.019041313   1.676175e-11
## [500,2e+05)    6.399594e-10   9.403051e-03    0.005044056   2.051812e-11
##             Next.DegreeMD Next.DegreeMD2 Next.DegreeME Next.DegreeMFA
## [1,100)      1.561545e-01   1.244549e-02  6.518632e-03   3.221266e-02
## [100,250)    1.067896e-01   9.215122e-03  3.596622e-02   1.205758e-02
## [250,500)    4.098533e-06   1.175684e-06  4.742861e-05   1.708822e-06
## [500,2e+05)  2.450719e-02   4.235489e-07  1.741876e-02   1.192173e-06
##             Next.DegreeMHA Next.DegreeML Next.DegreeMLS Next.DegreeMM
## [1,100)       7.015607e-07  2.988515e-08   6.007307e-03  8.672418e-05
## [100,250)     7.975913e-09  6.796248e-06   8.260364e-03  2.098482e-05
## [250,500)     8.882581e-07  9.386947e-06   1.731239e-06  1.222167e-06
## [500,2e+05)   7.471225e-10  1.162903e-05   1.862733e-03  1.920639e-06
##             Next.DegreeMPA Next.DegreeMPH Next.DegreeMS Next.DegreeMSM
## [1,100)       1.492076e-02   4.824933e-03    0.20425336   5.034152e-07
## [100,250)     1.406638e-02   9.189698e-06    0.15531919   5.175065e-09
## [250,500)     1.992862e-06   2.587077e-06    0.01734782   5.298979e-11
## [500,2e+05)   1.840390e-06   2.960986e-06    0.01122140   5.776263e-09
##             Next.DegreeMSW Next.DegreeNDA Next.DegreeNONE Next.DegreePHD
## [1,100)       6.480561e-03    0.266867158      0.18169246     0.23056967
## [100,250)     2.170500e-02    0.065032713      0.19245692     0.20593454
## [250,500)     1.940135e-06    0.009991843      0.10656704     0.02437798
## [500,2e+05)   1.984675e-03    0.028555679      0.02402414     0.01933352
```

```
##             Next.DegreeSTM Next.DegreeTC Next.DegreeUBDS Next.DegreeUDDS
## [1,100)       4.678993e-09  2.108427e-02    7.728449e-03    5.749096e-05
## [100,250)     2.610076e-06  1.988923e-02    7.815329e-07    2.396742e-06
## [250,500)     1.640057e-11  5.231278e-05    3.636148e-06    3.771331e-03
## [500,2e+05)   1.053389e-10  2.176542e-03    6.457434e-07    8.731639e-07
##             Next.DegreeUMD Next.DegreeUMDS Next.DegreeUNKD
## [1,100)       1.137798e-02    1.273117e-04    1.810884e-02
## [100,250)     8.285980e-06    6.976571e-06    2.094375e-02
## [250,500)     1.569747e-06    2.784018e-06    4.636703e-06
## [500,2e+05)   2.592696e-03    4.478337e-06    2.992865e-06
##             AttendenceEvent1 Years.Since.Graduation  FY12Giving
## [1,100)           0.1966093            0.008192326 0.002004510
## [100,250)         0.2290953            0.008235403 0.001247048
## [250,500)         0.1568910            0.014790807 0.001668748
## [500,2e+05)       0.1899927            0.016789106 0.001665525
##               FY13Giving  FY14Giving   FY15Giving
## [1,100)     2.177748e-03 0.002453597 0.0018367120
## [100,250)   6.127965e-05 0.001190507 0.0008189432
## [250,500)   1.092868e-03 0.001455085 0.0008066031
## [500,2e+05) 1.046155e-03 0.001307870 0.0007111002
##
## Residual Deviance: 1542.939
## AIC: 2342.939
```

```
library(package = car)

Anova(mod.multinomial)
```

```
## Analysis of Deviance Table (Type II tests)
##
## Response: FY16GivingCat
##                         LR Chisq  Df Pr(>Chisq)
## Marital.Status            23.857  12  0.0212688 *
## Major                    179.930 176  0.4038481
## Next.Degree              179.709 184  0.5755883
## AttendenceEvent           32.357   4  1.617e-06 ***
## Years.Since.Graduation    28.595   4  9.449e-06 ***
## FY12Giving                31.821   4  2.081e-06 ***
## FY13Giving                18.727   4  0.0008894 ***
## FY14Giving                21.033   4  0.0003120 ***
## FY15Giving                27.311   4  1.720e-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 ~ Marital.Status + AttendenceEven
```

```
## # weights:  45 (32 variable)
## initial  value 1609.437912
## iter  10 value 1353.795899
## iter  20 value 1062.389882
```

```
## iter  30 value 1003.539294
## iter  40 value 982.045792
## iter  50 value 980.552379
## iter  60 value 980.251701
## final  value 980.206263
## converged
```

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

```
## Call:
## multinom(formula = FY16GivingCat ~ Marital.Status + AttendenceEvent +
##     Years.Since.Graduation + FY14Giving + FY15Giving, data = df)
##
## Coefficients:
##             (Intercept) Marital.StatusM Marital.StatusS Marital.StatusW
## [1,100)       -1.031517      0.01349558      -0.3247297       0.7221437
## [100,250)     -3.046350      0.36414997      -0.4654959     -10.8025809
## [250,500)     -5.971523      0.74969470      -0.3292222       2.0789415
## [500,2e+05)   -5.465117      0.17577879       0.1676555       1.8784757
##             AttendenceEvent1 Years.Since.Graduation   FY14Giving
## [1,100)            0.5262634            -0.01882572 0.0004828398
## [100,250)          0.9670546             0.02482281 0.0048809707
## [250,500)          1.8669257             0.03726599 0.0041893724
## [500,2e+05)        1.5823727             0.01740007 0.0054739693
##               FY15Giving
## [1,100)     -0.0016557980
## [100,250)    0.0006232432
## [250,500)    0.0021293643
## [500,2e+05)  0.0028739860
##
## Std. Errors:
##             (Intercept) Marital.StatusM Marital.StatusS Marital.StatusW
## [1,100)       0.4581529       0.3975094       0.4234467    9.287316e-01
## [100,250)     0.4891447       0.3839734       0.4474912    1.168224e-05
## [250,500)     0.5412881       0.3612359       0.5000579    6.963141e-01
## [500,2e+05)   0.5912825       0.4113796       0.4708799    7.451498e-01
##             AttendenceEvent1 Years.Since.Graduation  FY14Giving
## [1,100)            0.1842334            0.008121592 0.001654086
## [100,250)          0.2241122            0.008474052 0.001055501
## [250,500)          0.4977135            0.014287337 0.001188050
## [500,2e+05)        0.5147300            0.016063205 0.001100408
##               FY15Giving
## [1,100)     0.0014472073
## [100,250)   0.0007123643
## [250,500)   0.0007196183
## [500,2e+05) 0.0006509453
##
## Residual Deviance: 1960.413
## AIC: 2024.413
```

```
Anova(mod.multinomial.simple)
```

```
## Analysis of Deviance Table (Type II tests)
##
## Response: FY16GivingCat
```

```
##                         LR Chisq Df Pr(>Chisq)
## Marital.Status            24.125 12  0.0195592 *
## AttendenceEvent           41.829  4  1.810e-08 ***
## Years.Since.Graduation    23.068  4  0.0001227 ***
## FY14Giving                36.404  4  2.390e-07 ***
## FY15Giving                32.815  4  1.303e-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 ~ Marital.Status + AttendenceEvent + Years.Since.G
summary(mod.ordinal)
```

```
## formula:
## FY16GivingCat ~ Marital.Status + AttendenceEvent + Years.Since.Graduation + FY14Giving + FY15Giving
## data:    df
##
##  link  threshold nobs logLik  AIC     niter max.grad cond.H
##  logit flexible  1000 -981.89 1985.79 8(0)  4.98e-12 5.3e+06
##
## Coefficients:
##                           Estimate Std. Error z value Pr(>|z|)
## Marital.StatusM          0.2863800  0.2828325   1.013    0.311
## Marital.StatusS         -0.1133020  0.3118585  -0.363    0.716
## Marital.StatusW          0.8521188  0.6878345   1.239    0.215
## AttendenceEvent1         0.8070733  0.1423200   5.671 1.42e-08 ***
## Years.Since.Graduation   0.0088504  0.0056924   1.555    0.120
## FY14Giving               0.0044853  0.0007489   5.989 2.11e-09 ***
## FY15Giving               0.0033004  0.0005806   5.684 1.31e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##                       Estimate Std. Error z value
## [0,1)|[1,100)           1.5655     0.3398   4.607
## [1,100)|[100,250)       2.6358     0.3481   7.573
## [100,250)|[250,500)     4.3810     0.3799  11.531
## [250,500)|[500,2e+05)   5.5519     0.4221  13.152
```

```
library(package = ordinal)
mod.ordinal.simpler = clm(data = df, formula = FY16GivingCat ~ AttendenceEvent + Years.Since.Graduation
summary(mod.ordinal.simpler)
```

```
## formula:
## FY16GivingCat ~ AttendenceEvent + Years.Since.Graduation + FY14Giving + FY15Giving
## data:    df
##
##  link  threshold nobs logLik  AIC     niter max.grad cond.H
```

```
##  logit flexible  1000 -985.92 1987.84 8(0)  4.74e-12 1.2e+06
##
## Coefficients:
##                          Estimate Std. Error z value Pr(>|z|)
## AttendenceEvent1        0.8242679  0.1419419   5.807 6.36e-09 ***
## Years.Since.Graduation 0.0136940  0.0051197   2.675  0.00748 **
## FY14Giving              0.0045819  0.0007578   6.046 1.48e-09 ***
## FY15Giving              0.0033772  0.0005814   5.809 6.29e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##                         Estimate Std. Error z value
## [0,1)|[1,100)            1.5433     0.1602   9.631
## [1,100)|[100,250)        2.6067     0.1758  14.825
## [100,250)|[250,500)      4.3477     0.2298  18.919
## [250,500)|[500,2e+05)    5.5259     0.2939  18.805
```

Ordinal Non-Proportional

Section 1: Introduction

Section 2: EDA

Section 3: Statistical Modeling

Section 4: Final Remarks