Stat 210 Project

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Introduction

Background and Significance: There has been recent discussion on adequate female representation in film. Many in the film industry have recently praised the increased representation of women in film (Nolfi,2017). For a while Hollywood produced very little movies with female protagonists; let alone movies with appropriate representation of women (Goodman, 2017).However, merely having female protagonists does not paint the full picture if whether a movie actually does a good job in female representation. Many have used the so-called Bechdel test to make this judgement. This test was developed by Allison Bechdel in 1985 and has recently become a digital sensation (Hickey, 2014).The Bechdel test is a simple test which deems that a movie has adequate female character in their film if it passes the following three criteria: (1) it has to have at least two women in it, who (2) who talk to each other, about (3) something besides a man (https://bechdeltest.com/) .

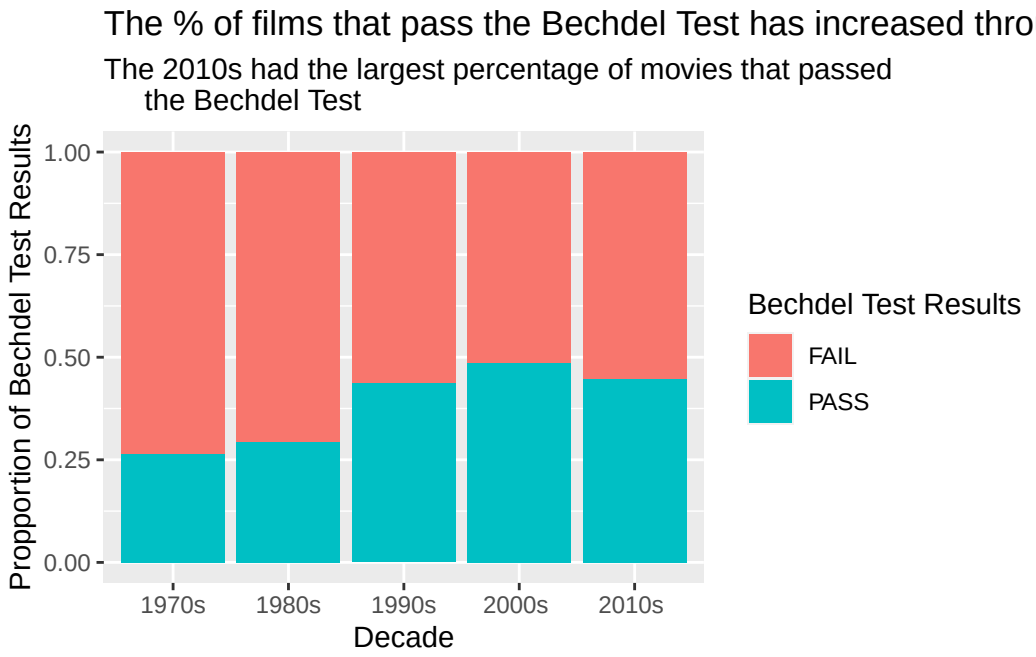
Many have argued that there has been significant increase of female representation throughout the decades thanks to increased diversity initiatives and more women at the helm of the film industry (UCLA-Hollywood-Diversity-Report-2022-Film).

Research Question & Hypothesis We're interested in evaluating what variables are important in predicting whether a movie passes or fails the Bechdel test. We are interested specifically if the time period in which a movie was released predicts whether a movie passes the Bechdel test. In other words, does the decade a movie was released predict whether it passes the Bechdel test while controlling for other pivotal variables in our model? As shown by recent news and media, more modern movies seem to have more increased representation of women in their films. Thus, we predict that the time period in which a movie was released will play a significant role in whether the movie fails or passes the Bechdel test. More specially, we predict that movies released in the 2000's and 2010's have a greater percentage of movies that pass the Bechdel rather than those that came out in the 20th century represented in our data set.

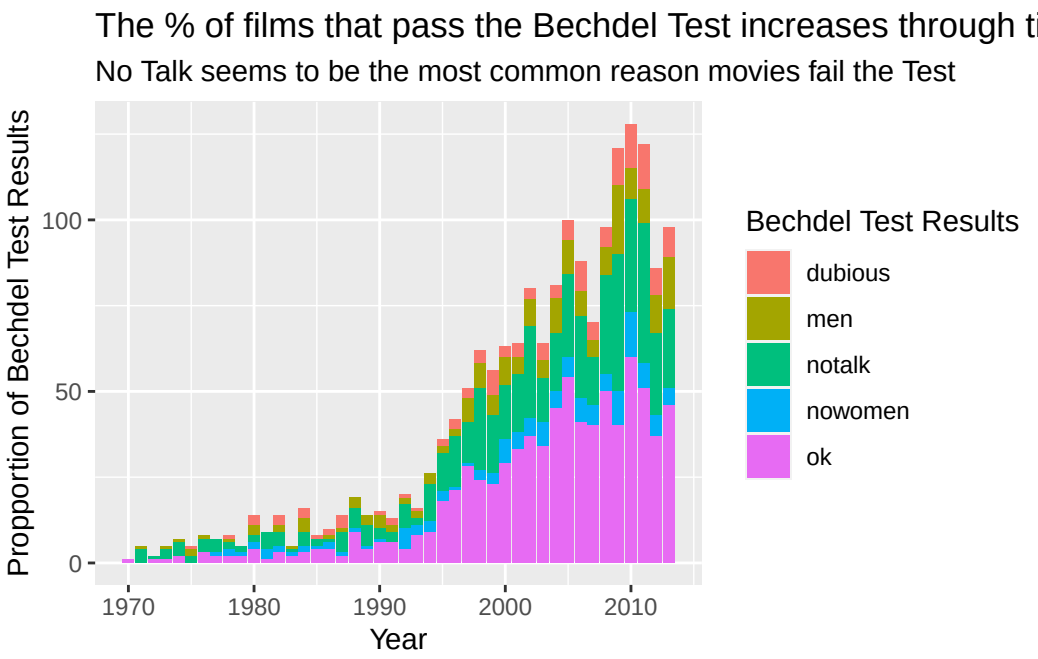
Data To explore our research quetsion, we'll be using a data set used in the FiveThirtyEight story titled "The Dollar-And-Cents Case Against Hollywood's Exclusion of Women" (Hickey,

2014). The data set includes observations from 1794 films that were released between 1970-2013.The data set was organized by combining data from two major sources. One of them came from the BechdelTest.com: a website operated by committed moviegoers who analyze films and ascertain if they pass the Bechdel test. To provide financial information for the chosen films, the FiveThirtyEight team gathered data from the website The-Numbers.com, a leading site for box office and budget data. The finalized *movies.cv* data set includes information detailing the title of the film, the year it was released, its domestic gross, budget and international gross (both accounting for inflation at the time of data collection and without). See Data Dictionary for more details.Furthermore, for our purposes, the data set also includes two important columns regarding whether the movie passed or failed the Bechdel test. The column "binary" specifically states whether the movie passed or failed the Bechdel test in a binary fashion. The column "clean_test" goes a bit more in detail, regarding how the film failed the Bechdel test or if it was unclear whether the movie passed or not. The clean test variable has five levels: ok (Passed), no women (No women in the film), dubious (unclear result), no talk(women did not talk to each other), and men (women only talked about men.)We created new variables for the purposes of our analysis. For starters, we created a decades variable that detailed which decade the given film was released in. The variable ended up having 5 different levels: 1970s, 1980s, 1990s, 2000s and 2010s. We also created a new variable titled passfail which is essentially the same as our binary variable but instead uses dummy values to illustrated whether the movies passed (passfail=1) failed (passfail=0) the Bechdel test. We excluded 18 observations from our final analysis. These observations had no values for their total domestic gross and total budget. These are variables of interest that important variables that we want to control for .Since we still had 1776 left in our data set, our statistical analyses will not be greatly affected by the removal of these observations.

Exploratory Data Analysis



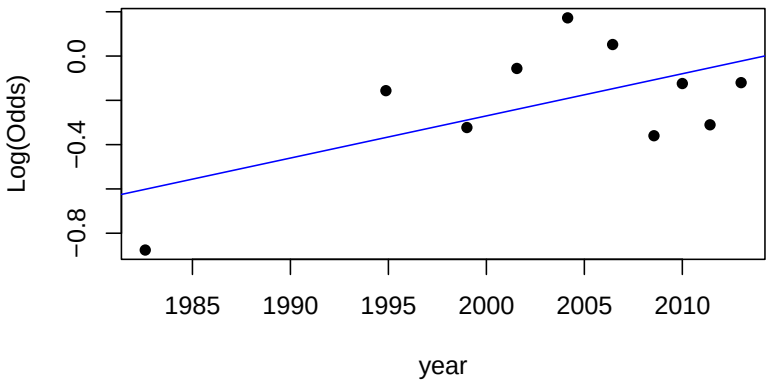
We can see above that there is general upward trend across the decades with an increased percentage of movies that pass the Bechdel test. We see, specifically that the movies from our data set that premiered in the 2000s, about 48% of the films passed the Bechdel test. The 2010s performed in a similar fashion, with 45% of the films released passing the Bechdel test (it is important to note however that this data set only includes movies till 2013, thus it does not paint the full picture of female representation in film from this decade) The decade with the lowest percentage of movies that passed the Bechdel test was the 1970s, with only 25% passing. Below we also see a similar trend when looking years as our independent variable and with clean test as our dependent variable, revealing that films released in the 21st century have a higher percentage of movies that pass the Bechdel test. Moreover, we also see that no women talk seems to be the most common reason for a movie to fail the Bechdel test.



#Methodolody We are interested in running a regression model in order to evaluate whether the time period a given film was released. Furthermore, we are interested in using the binary variable "passfail" as our outcome variable–meaning we will use a logistic regression model. Furthermore, we believe this is an appropriate model since our data passes the independence assumption. We can assume that independence is met because our observations are most likely not correlated with each other. Each of our movie titles are independent from each other and knowing something about one of our observations does not reveal anything substantial about another observation.

For our outcome variable, we chose to use the binary version detailing whether given film's performance on the Bechdel test rather than our clean_test variable because we felt that a binary outcome variable would generate a simpler model. Furthermore, if we ran a logistic model with the clean_test as our outcome variable, we would have to use a multinomial regression model to test out our research question. A multinomial regression model would not make sense in this context the since the independence of irrelevant alternatives assumption would be violated. This assumption assumes that, in a multinomial logistic regression model, the relative odds of choosing one option over another should not be influenced by the inclusion or exclusion of an additional option. This does not make sense since the inclusion or exclusion of a Bechdel test failing category could have an effect on our final analysis. For example, if a given film with plentiful female representation that was released in 2013 (which according to our hypothesis means it has a greater chance of passing the Bechdel test) was included our model but the only two categories taken accounted for whether "notalk" and "dubious," our model would predict it was it fit the dubious category. However, if the "ok" was included in the mix, this would change our predictive probablity.

Next, we evaluated whether to use the "year" or "decade" variable for our investigation. On one hand, the year variable is continuous, allowing us to have greater statistical power. On the other hand, the categorical "decade" variable applies more to our question of interest and the context of the data set. The film industry has gone through distinct decade period; many film research that tackles chronically change discuss the changes through decades, not years. To decide which variable to use, we checked whether our continuous variable "year" passed the linearity assumption.



As shown above, the points are not evenly scattered therefore we have decided that this is not an appropriate variable to use in our model and instead will use decade. We could have transformed the variable, quadratically for example in order to pass this linearity assumption. However, this will complicate our interpretation of our model gravely since our outcome variable of interest would be transformed. Thus, for the purposes of our investigation, we will use the decades variable. For our other predictor variables, we are interested in using international gross, domestic gross, budget and an interaction between international gross and domestic gross. These variables have been shown to affect Bechdel test results in the past (Hickey, 2014) thus we thought it would be smart to control for these variables in our model. Furthermore, we chose to introduce an interaction term between domestic gross and international gross because these two variables tend to depend on each other (when a movie does well internationally this depends on its domestic sucesss since movie industries usually stop investing in marketing for the film if the film performs poorly domestically first).

We also checked to see if the linearity condition was met for our other continuous predictors (see Appendix for linearity plots for all linearity plots). Only the budget variable passed the linearity assumption. The linearity condition was met for our predictors dom_Gross2013 and budget_Gross2013. However, it was not met for our Int_Gross2013 variable. In order to deal with this violation of our linearity assumption, we applied a log transformation to our

int_Gross variable. Since, this is not a particular variable of high interest, our final result interpretations' simplicity won't be gravely affected.

This is our proposed model that we will use to investigate our research question:

For each deccade the film premiered in i,

$p/(1-p)$ = Odds of passing the Bechdel Test

$log(p / (1-p) = _0 + _1(Budget)_i + _2(log(IntGross))_i + _3(log(DomGross)) + _4I(decade1980s)_i + _5I(decade1990s)_i + _6I(decade2000s)_i + _7I(decade2010s)_i + _8(log(IntGross))_i * log(DomGross_i) $

Results

Hypothesis Test We ran a logistic regression model using the final model discussed in the previous section to see if decade alone can predict whether a movie passes or fails the Bechdel test. We will then run a hypothesis test to see if one of our decade categorical predictors is associated with the score a film gets on the Bechdel test.

Our model is as follows. For each deccade the film premiered in i,

$p/(1-p)$ = Odds of passing the Bechdel Test

$log(p/(1-p) = \beta_0 + \beta_1(Budget)_i + \beta_2(log(IntGross))_i + \beta_3(DomGross) + \beta_4 I(decade1980s)_i + \beta_5 I(decade1990s)_i + \beta_6 I(decade2000s)_i + \beta_7 I(decade2010s)_i + \beta_8(log(IntGross))_i * DomGross_i$

We will run a hypothesis at the $a = 0.05$ level.

Null hypothesis:

H_0 : All of our β terms for decade (β_4, β_5, β_6 or β_7) are equal to zero.

There is not sufficient evidence to suggest that the decade in which a movie premiered is associated with differential odds of the moving passing the Bechdel test, while controlling for all of the variables listed in the previous section.

Alternative Hypothesis:

H_1: At least one of our β terms for decade (β_4, β_5, β_6 or β_7) is not equal to zero.

```
# A tibble: 4 x 6
  term                                    Resid~1 Resid~2    df Devia~3  p.value
  <chr>                                     <dbl>   <dbl> <dbl>   <dbl>    <dbl>
1 passfail ~ decade + budget_Gross2013 +~    1767   2367.    NA    NA   NA
2 log(int_Gross2013) * log(dom_Gross2013)    1771   2397.    -4   -29.4  6.39e-6
3 passfail ~ budget_Gross2013 + log(dom_~    1767   2367.    NA    NA   NA
```

```
4 log(int_Gross2013) * log(dom_Gross2013)    1771   2397.    -4   -29.4  6.39e-6
# ... with abbreviated variable names 1: Resid..Df, 2: Resid..Dev, 3: Deviance
```

```
[1] 5.31495
```

We will be conducing an F test for this formal hypothesis test. The F statistic is 5.31495 and falls under an F distribution with 4 numerators of degrees of freeom and 1776 denominator degrees of freedom. We reject the null hypothesis in this case since our p value is less than 0.05, meaning that at least one of our decade predictor levels has a slope that is not 0. There is sufficient evidence to suggest that the decade in which a movie premiered in is associated with differential odds of the moving passing the Bechdel test, while controlling for all of the variables listed in the previous section (andadjusting for log(domGross), log(intgross) and log(intgross)* log(domGross.)

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-3.0978128	2.5054732	-1.2364182	0.2163031
decade1980s	0.1186899	0.3735990	0.3176932	0.7507176
decade1990s	0.8667758	0.3391740	2.5555490	0.0106020
decade2000s	1.0851180	0.3314832	3.2735234	0.0010622
decade2010s	0.9558745	0.3392631	2.8175022	0.0048399
budget_Gross2013	0.0000000	0.0000000	-4.8974955	0.0000010
log(dom_Gross2013)	0.2098589	0.1789721	1.1725785	0.2409649
log(int_Gross2013)	0.0616945	0.1702408	0.3623954	0.7170566
log(dom_Gross2013):log(int_Gross2013)	-0.0077444	0.0095595	-0.8101225	0.4178698

Coefficient Interpretations

While controlling for the variables in our model, the odds of passing the Bechdel test for a movie that premiered in the 1990s is estimated to be 2.3379 times the odds of a film that was released in the 1970s (adjusting for our transformed variables).

While controlling for the variables in our model, the odds of passing the Bechdel test for a movie that premiered in the 2000s is estimated to be 2.959 times the odds of a film that was released in the 1970s (adjusting for our transformed variables).

While controlling for the variables in our model, the odds of passing the Bechdel test for a movie that premiered in the 2010s is estimated to be 2.601 times the odds of a film that was released in the 1970s (adjusting for our transformed variables).

Predictive Power

Even though our result was significant, we also want to check for the predictive power of our model. We will thus check the obtain predicted probabilities of success for our binary variable "passfail." We will impose a threshold of 0.5 as our classifier. We will check the sensibility and sensitivity for our model to asses its predictive power and construct an ROC curve to show

how specificity and specificity change as our discrimination threshold changes (see curve in Appendix).

	0	1
Fail	666	396
Pass	316	398

```
[1] 0.5012594
```

```
[1] 0.6782077
```

To further evaluate the predictive power of our model, we also calculated the sensitivity and specificity of our model. Our specificity was 0.6782077 Furthermore, our sensitivity was 0.5012594.

Discussion

In this section you'll include a summary of what you have learned about your research question along with statistical arguments supporting your conclusions. In addition, discuss the limitations of your analysis and provide suggestions on ways the analysis could be improved. Any potential issues pertaining to the reliability and validity of your data and appropriateness of the statistical analysis should also be discussed here. Lastly, this section will include ideas for future work.

Ultimately, our model demonstrates that there is an association between the decade in which a film was released and whether it passes or fails the Bechdel test. We observed this through our hypothesis test which demonstrated that movies that came out in the 2000s and 2010s were more likely to pass the Bechdel rather than movies that came out in the 1970s. The logic behind this conclusion in the summary statistics of our data (48% of the films that premiered in the 2000s passed the Bechdel and % of the movies that came out in the 2010s passed the test while 25% of the films that premiered in the 1970s passed the Bechdel test).

We can conclude, therefore, that the time period in which a movie came out in does in fact hold predictive power in predicting whether the given film passed or failed the Bechdel test. Perhaps the movie industry has indeed progressed throughout time and has released films with more adequate female representation in film. This could be a result of the recent diversity campaigns in Hollywood and a result of an increase of women workinh in the film industry, allowing for more adequate representationf for female characters. Therefore, we can conclude that it is more likely for a film that premiered in the 2000s to pass the Bechdel test than a film that premiered in the 1970s. We did not see the case that movies that came out in the 2010s were more likely to pass the Bechdel test than movies that premiered in the 1970s. However, thus could be more due to the fact that our data set only contained values from 2010-2013. Perhaps,

if we conducted this same analysis with a new data set that included films frmo 2010-2019, we could see a more similar result to the case with the 2000s.

However, the predictive power of our model was, overall, pretty weak. Our model only detected 50% of the films that in actuality passed the Bechdel test as shown by our sensitivity calculation. Our model did a slight better job at predicting which movies failed the Bechdel test as shown by the fact that our model predicted 68% of films that in actuality failed the Bechdel test. Usually, a really good predictive model would have a combined score. This is further demonstrated by the fact that our AUC was 0.626768 which means that our test performed slightly better than a test that would predict whether a given film passed or failed the Bechtel test completely by chance. Usually a AUC score of 0.7-0.8 is needed to show acceptable discrimination. (Medley, 2010).

Our model most likely did not obtain enough predictive power because of the limitations our investigation faced. Firstly, our model had an uneven amount of films that premiered in our decades of interest. We had 54 observations for the 1970s, 125 observations for 1980s, 337 for 1990s, 840 for the 2000s and 438 for the 2010s (see Appendix for summary stats). This could have in turn affected our statistical inference since there was in balance of obervations for eahc level of our predictor variable. Another limitation is the fact some of the coefficients in our model are pretty difficult to interpret. This can be seen with our transformed variable of domestic gross. If anyone wanted to use to inteprtret thhis speicific coefficinet from our model, the interpretation would be pretty lackluster. Lastly, another limitation includes the lack of variables in our data set. Our data set only included 15 variables to begin with which have us a limited amount of variables to choose from. There are many future directions that could be taken with this investigation. For starters, it could be interetsing to have a dataset that represents more decades (from the 1920s till 2020s). Furthermore, future investigations should include more variables in their model. It could be interesting to see if the number of women working on the film is associated with the film's score on the Bechdel tets. The film genre could also be an interetsing variable to look at; it is possible that movies from certain genres are predicted to have higher odds of passing the Bechdel test than others.

Sources

https://socialsciences.ucla.edu/wp-content/uploads/2022/03/UCLA-Hollywood-Diversity-Report-2022-Film-3-24-2022.pdf

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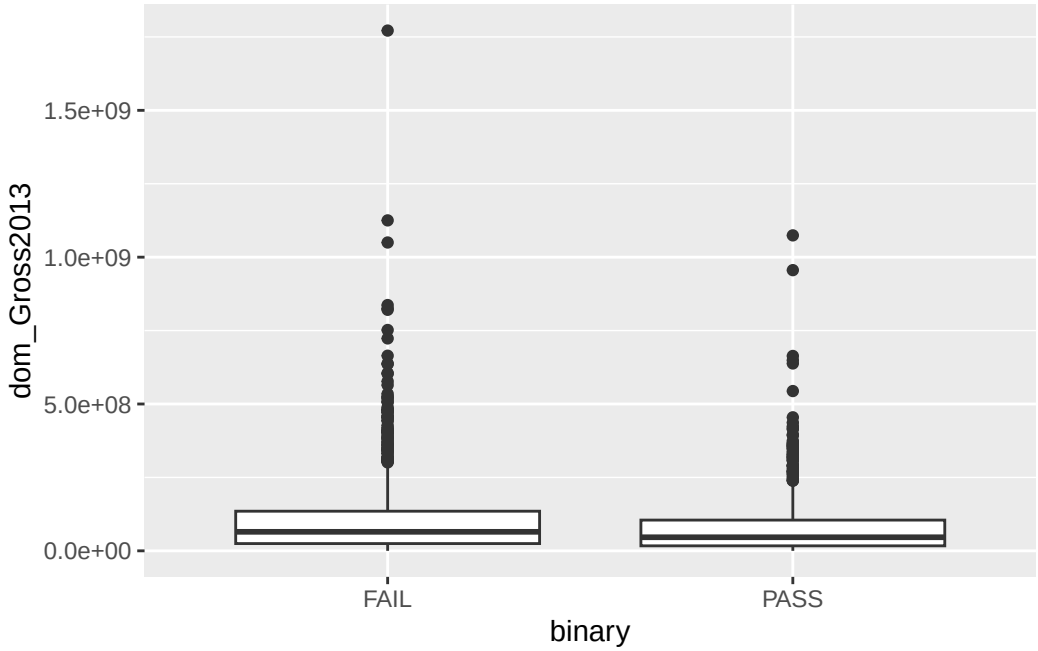
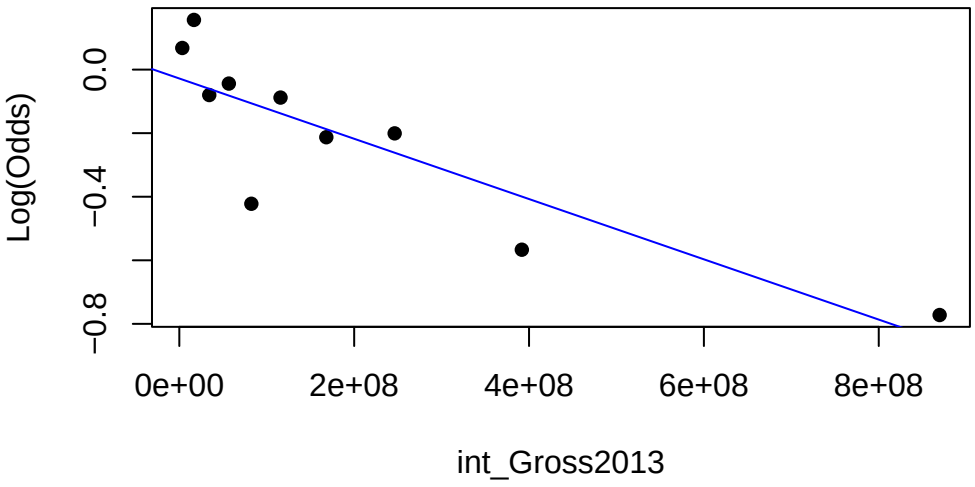
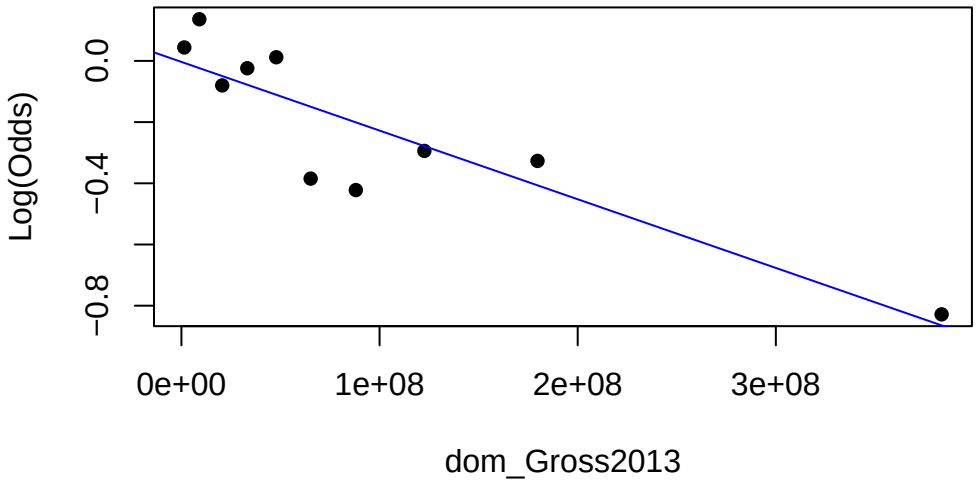
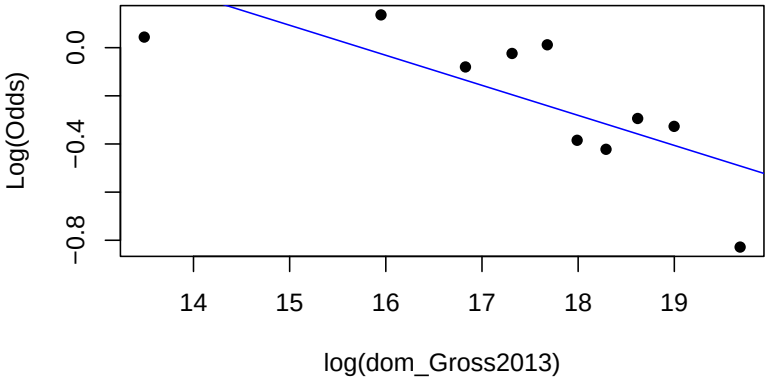
https://ew.com/oscars/2017/07/03/oscars-2017-new-members-diversity-push/

Appendix






Log(Odds)
0.0
−0.4
−0.8
0e+00
1e+08
2e+08
3e+08
dom_Gross2013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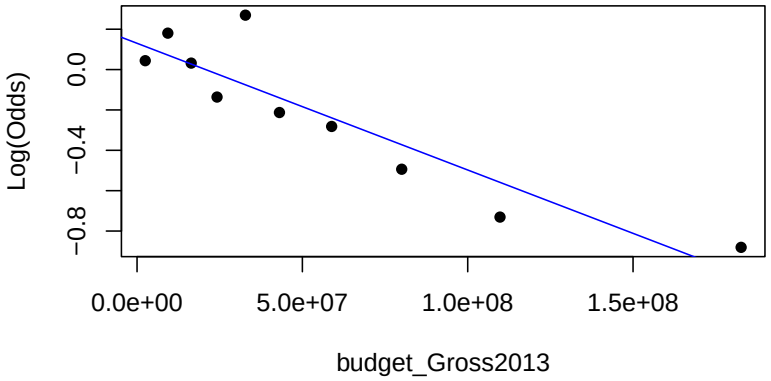
−0.4
−0.8
14
15
16
17
18
19
log(dom_Gross2013)


Log(Odds)
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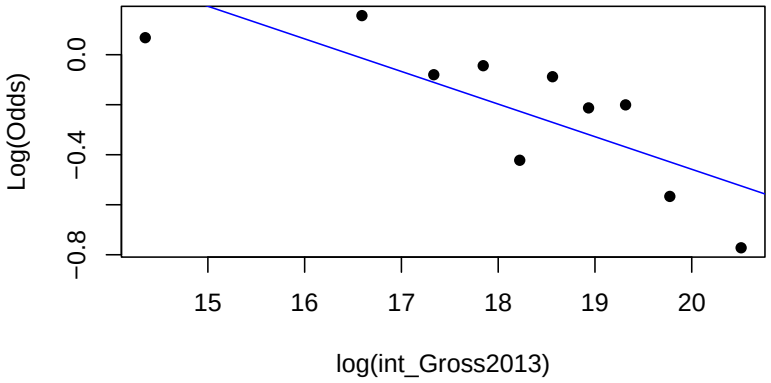
−0.8
0.0e+00
5.0e+07
1.0e+08
1.5e+08
budget_Gross2013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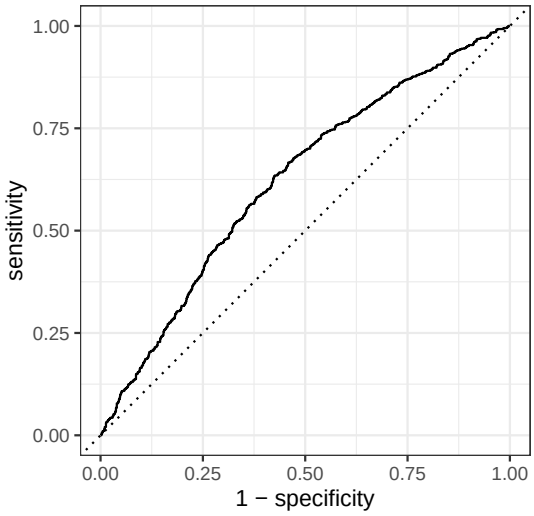
20
log(int_Gross2013)


1.00
0.75
0.50
0.25
0.00
sensitivity
0.00
0.25
0.50
0.75
1.00
1 − specificity