

Problem Set 2

Applied Stats II

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Instructions

- Please show your work! You may lose points by simply writing in the answer. If the problem requires you to execute commands in **R**, please include the code you used to get your answers. Please also include the **.R** file that contains your code. If you are not sure if work needs to be shown for a particular problem, please ask.
- Your homework should be submitted electronically on GitHub in **.pdf** form.
- This problem set is due before 23:59 on Sunday February 18, 2024. No late assignments will be accepted.

We're interested in what types of international environmental agreements or policies people support (Bechtel and Scheve 2013). So, we asked 8,500 individuals whether they support a given policy, and for each participant, we vary the (1) number of countries that participate in the international agreement and (2) sanctions for not following the agreement.

Load in the data labeled **climateSupport.RData** on GitHub, which contains an observational study of 8,500 observations.

- Response variable:
 - **choice**: 1 if the individual agreed with the policy; 0 if the individual did not support the policy
- Explanatory variables:
 - **countries**: Number of participating countries [20 of 192; 80 of 192; 160 of 192]
 - **sanctions**: Sanctions for missing emission reduction targets [None, 5%, 15%, and 20% of the monthly household costs given 2% GDP growth]

Please answer the following questions:

1. Remember, we are interested in predicting the likelihood of an individual supporting a policy based on the number of countries participating and the possible sanctions for non-compliance.

Fit an additive model. Provide the summary output, the global null hypothesis, and p -value. Please describe the results and provide a conclusion.

```
1 # load data
2 load(url("https://github.com/ASDS-TCD/StatsII_Spring2024/blob/main/
  datasets/climateSupport.RData?raw=true"))
3 # check the data
4 head(climateSupport)
5 summary(climateSupport)
6 str(climateSupport)
7 # Fit an additive model
8 library(mgcv)
9 # Forced conversion from character vector to logical vector
10 as.logical(ifelse(climateSupport$choice == "Supported", 1, 0))
11 # Convert counties and sanctions to unordered factors
12 climateSupport$countries <- factor(climateSupport$countries, ordered
  = FALSE)
13 climateSupport$sanctions <- factor(climateSupport$sanctions, ordered
  = FALSE)
14 # check the data
15 str(climateSupport)
16 # Fit a logistic regression model
17 model <- glm(choice ~ .,
18               data = climateSupport,
19               family = "binomial")
20 # Display summary output
21 summary(model)
```

Result:

```
Call:
glm(formula = choice ~ ., family = "binomial", data = climatesupport)
```

Coefficients:

	Estimate	Std. Error	z value	Pr(> z)	
(Intercept)	-0.27266	0.05360	-5.087	3.64e-07	***
countries80 of 192	0.33636	0.05380	6.252	4.05e-10	***
countries160 of 192	0.64835	0.05388	12.033	< 2e-16	***
sanctions5%	0.19186	0.06216	3.086	0.00203	**
sanctions15%	-0.13325	0.06208	-2.146	0.03183	*
sanctions20%	-0.30356	0.06209	-4.889	1.01e-06	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

```
Null deviance: 11783 on 8499 degrees of freedom
Residual deviance: 11568 on 8494 degrees of freedom
AIC: 11580
```

```
Number of Fisher scoring iterations: 4
```

Intercept indicates that when all independent variables are 0, the estimated logarithmic probability of the dependent variable is -0.27266.

The estimated value of countries80 of 192 is 0.33636, indicating that when a country is one of 80 out of 192 countries, the logarithmic probability of the dependent variable increases by 0.33636.

The estimated value of countries 160 of 192 is 0.64835, indicating that when a country is one of 160 out of 192 countries, the logarithmic probability of the dependent variable increases by 0.64835.

The estimated value of sanctions5% is 0.19186, indicating that when the severity of sanctions is 5%, the logarithmic probability of the dependent variable increases by 0.19186.

The estimated value of sanctions15% is -0.13325, indicating that when the severity of sanctions is 15%, the logarithmic probability of the dependent variable decreases by 0.13325.

The estimated value of sanctions20% is -0.30356, indicating that when the degree of sanctions is 20%, the logarithmic probability of the dependent variable decreases by 0.30356.

From the results, it can be seen that the P-values of all coefficients are less than the commonly used significance level of 0.05. This means that all coefficients are significant, and we have sufficient evidence to reject the assumption that the coefficients are zero, meaning that their impact on the dependent variable is significant.

```
1 #Testing the Global null Hypothesis and its p-value
2 #Testing the Global null Hypothesis
3 global_null_hypothesis <- summary(model)$null.deviance
4 cat("Global null hypothesis:", global_null_hypothesis, "\n")
5 # Obtain p-value
6 model_p_value <- summary(model)$coefficients[, "Pr(>|z|)"]
7 cat("Model p-value:", model_p_value, "\n")
8 # Obtain the number of independent variables in the model
9 df.null <- length(coef(model)) - 1
10 # Calculate the p-value of the global null hypothesis
11 global_null_p_value <- pchisq(summary(model)$null.deviance, df = df.null, lower.tail = FALSE)
12 cat("Global null hypothesis p-value:", global_null_p_value, "\n")
```

Result:

Global null hypothesis: 11783.41

Model p-value: 3.635432e-07 4.051815e-10 2.397037e-33 0.002025651 0.0318345
1.014753e-06

Global null hypothesis p-value: 0

In this model, the global null hypothesis is that all coefficients of the explanatory variables are equal to zero, indicating no influence of any explanatory variable on the outcome.

According to the provided results, the p-value for the global null hypothesis is 0,

indicating that we can reject the global null hypothesis.

2. If any of the explanatory variables are significant in this model, then:

- (a) For the policy in which nearly all countries participate [160 of 192], how does increasing sanctions from 5% to 15% change the odds that an individual will support the policy? (Interpretation of a coefficient)

```
1 #2a:
2 # Extract coefficients from the model
3 coefficients <- coef(model)
4 # Extracting coefficients related to interaction terms
5 interact_coefficients <- coefficients[grepl("countries160 of 192:
  sanctions", names(coefficients))]
6 # Calculate the probability logarithm at 5% and 15% sanction levels
7 log_odds_5percent <- coefficients["(Intercept)"] + coefficients["
  countries160 of 192"] + coefficients["sanctions5%"]
8 log_odds_5percent
9 log_odds_15percent <- coefficients["(Intercept)"] + coefficients["
  countries160 of 192"] + coefficients["sanctions15%"]
10 log_odds_15percent
11 # Calculate the change in probability
12 odds_change <- exp(log_odds_15percent - log_odds_5percent)
13 # Print results
14 cat("As sanctions increase from 5% to 15%, the probability of
  individuals supporting policies changes as follows:", odds_change
  , "\n")
```

Result:

As sanctions increase from 5% to 15%, the probability of individuals supporting policies changes as follows: 0.7224531

- (b) What is the estimated probability that an individual will support a policy if there are 80 of 192 countries participating with no sanctions?

```
1 #2b: Calculate the estimated probability
2 log_odds_80_no_sanctions <- coef(model)['(Intercept)'] + coef(model)[
  'countries80 of 192']
3 prob_80_no_sanctions <- exp(log_odds_80_no_sanctions) / (1 + exp(log_
  odds_80_no_sanctions))
4 cat("Estimated probability of 80 countries without sanctions:", prob_
  80_no_sanctions , "\n")
```

Result:

Estimated probability of 80 countries without sanctions: 0.5159191

(c) Would the answers to 2a and 2b potentially change if we included the interaction term in this model? Why?

- Perform a test to see if including an interaction is appropriate.

```
1 # 2c: Test interaction
2 model_interaction <- glm(choice ~ countries*sanctions,
3                           data = climateSupport,
4                           family = "binomial")
5 summary(model_interaction)
6 # Use anova() to compare models or view AIC/BIC
7 anova(model, model_interaction, test="Chisq")
```

Result:

```
call:
glm(formula = choice ~ countries * sanctions, family = "binomial",
    data = climateSupport)

Coefficients:
                Estimate Std. Error z value Pr(>|z|)
(Intercept)      -0.27469    0.07534   -3.646  0.000267 ***
countries80 of 192    0.37562    0.10627    3.535  0.000408 ***
countries160 of 192   0.61266    0.10801    5.672  1.41e-08 ***
sanctions5%         0.12179    0.10518    1.158  0.246909
sanctions15%        -0.09687    0.10822   -0.895  0.370723
sanctions20%        -0.25260    0.10806   -2.338  0.019412 *
countries80 of 192:sanctions5%  0.09471    0.15232    0.622  0.534071
countries160 of 192:sanctions5% 0.13009    0.15103    0.861  0.389063
countries80 of 192:sanctions15% -0.05229    0.15167   -0.345  0.730262
countries160 of 192:sanctions15% -0.05165    0.15267   -0.338  0.735136
countries80 of 192:sanctions20% -0.19721    0.15104   -1.306  0.191675
countries160 of 192:sanctions20% 0.05688    0.15367    0.370  0.711279
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 11783  on 8499  degrees of freedom
Residual deviance: 11562  on 8488  degrees of freedom
AIC: 11586

Number of Fisher Scoring iterations: 4
```

Analysis of Deviance Table

```
Model 1: choice ~ countries + sanctions
Model 2: choice ~ countries * sanctions
      Resid. Df Resid. Dev Df Deviance Pr(>Chi)
1          8494      11568
2          8488      11562  6    6.2928  0.3912
```

The chi-square statistic between the two models is 6.29, with 6 degrees of freedom and a p-value of 0.39. This p-value suggests that we cannot reject the possibility that the difference between the two models is due to randomness, and therefore it can be argued that the inclusion of an interaction term in the

model is unnecessary. So in this case it is not appropriate to add an interaction term and therefore there will be no change in the answers for 2a and 2b.