**Generalised Linear Model assignment**

Researchers are interested in which variables affect the reproductive success (number of eggs) of a fish species. They collected data in two years, 2010 and 2011, and recorded if the female who laid the eggs was dominant or not, and her body length and age. The data set is available as ‘data.fish.csv’.

Start with reading the data into R and look at the effects of age on reproductive success. Keep it simple and look at the data from 2011 only.

a. Visualise the relationship. Write down any patterns you observe which may affect your choice of test.

-There is a high concentration of zeros.

-It is bounded by zero

-no homogeneity in the variance

-we have count data (which suggest using a log-link function, )

- a non-linear relationship

b. What type of data is the response variable and what distribution does it follow?

The data is count data, and is discrete.

It is also highly right-skewed in it’s distribution.



c. One potential problem are the many zeros in the data set. What is the term for this type of data sets and how can you deal with it?

The term for this type of data set is

How to deal with it:

* Exclude the zeros
* Log Transform data
* Apply a generalized linear regression with a Poisson Distribution.

d. Let’s take a pragmatic approach and only select the fish with eggs (number of eggs > 0).

Let’s explore two approaches to deal with our non-normal data type.

First let’s take a linear approach modelling approach.

Approach 1, LM

e. log transform the response variable and perform a linear model. Check the model fit. Do you think we can use a linear model for the transformed data set? Is age a significant predictor of reproductive success?

For the analysis of the linear regression we used the dataset d1 (without all 0´s)

**Model fit:**

The model fits the data as the p-value for the F-test is p < 0.001 indicating that the model is likely significant. The F-test also shows that the beta (age) is likely different from zero.

*Adjusted R^2*: 45.34 % of the variance in log(egs) can be explained by age.

Age is a significant predictor of reproductive success as the p-value for the t-test is < 0.001. This shows that beta (age) is likely different from zero.

Also the F-Test shows that age I significant at an alpha = 1% significance level. We can use the F-test to analyse if beta (age) is significant as we only have one estimator. If we have mor than one estimator the F-test would tell us if any of the coefficients are nonzero (joint significance)

**Interpretation age:**

If we increase age by one year, holding everything constant, the number of eggs increase by 39.82%. (percentage interpretation as eggs is log transformed)

We just used the regression without the zeros

Log transformation is not appropriate because one cannot take a log of zero and therefore we addition an arbitrary amount to the response variable.

Other reasons:

f. Make a plot of the transformed data and fit the predicted values. Take care making the graph and pay attention to detail.

The predicted values, indicated by the linear regression, suggest that reproductive age begins at approximately 6 years of age, but this is not true, given that our data > 0, only occurs at ages greater than ~12 years.

Approach 2, GLM

g. The second approach is to use a generalised linear model approach. What are the similarities and what are the differences with the earlier linear model approach?

**We will do this after we’ve read the reading.**

**Similarities:**

* Both models have linear predictors
* Both models try to model estimators

**Differences:**

Linear model:

* Residuals are normally distributed with equal variance at all values of the x variables
* Uses least squares to fit the model to the data

GLM

* Uses maximum likelihood to estimate parameters
* Uses log-likelihood ratio test to test the parameters
* Residuals do not have to be normally distributed
* Variances can be unequal
* Allows to include non-linearity through the link function

Why would you prefer this approach over a transformation and linear model?

Why is it better than a linear model

Often our data violates the assumption of normality of errors.

For instance, count, binary and proportion data are bounded and/or discrete and therefore have errors that are not normally distributed. If we do not take this into consideration the results can be biased, underpowered or difficult to interpret.

GLM allows to consider the non-normality of the errors.

Moreover count, proportion and binary data often have non-linear relationships with their explanatory variables. GLM enable to include non-linearity through the link function.

Why is it better as a transformed linear model?

Often we can transform the data to receive a linear error distribution. As stated above a log transformation is not appropriate because one cannot take a log of zero (always the case for binary and proportion data) and therefore we addition an arbitrary amount to the response variable.

h. Perform a generalised linear model looking at the effects of age on the number of eggs and interpret the output. What scale are the parameters estimates in? Report the slope estimate in the correct units.

Estimates from summary(glm1): slope = 0.336106, and intercept = -1.342074. These estimates are in a log scale, given that the Poisson family applies a log link function.

Considering this, and the inverse of the log link function, our parameters can be estimated in the original scale given the following equation:

Thus slope estimate is equal to 1.3995

And intercept estimate is equal to 0.2613

**Interpretation**

i. Plot the data and the fitted curve. Try plotting the fitted model in two ways:

• use the ‘$fitted.values’ to extract them for the values in the model output\*

Line isn’t displaying on graph.

• use the predict() function where you need to input the model output, a list of values for which you want to have predicted values and set type = “response”). The latter method can give a much smoother curve if the fitted values in the response variable are very far apart.

Overdispersion occurs if the variance increases more than predicted.

j. Is overdispersion a problem in this data set? Estimate by dividing the $deviance by $df/residual.

Result?

k. Such overdispersion can be taken into account by running a so called quasipoisson link function. Re run with , family = "quasipoisson".

Compare both “poisson” and "quasipoisson" outputs and add the predicted curve to the plot.

Are they different? (HINT if you used predict() you can subtract the values from the poisson model from the quasipoisson to see how different they are).

We stick with the ‘poisson’ error link for now.

l. Let’s look at another variable and see if it can explain the relationship better. Add body.length

Run different subsets of models including both variables, either and non. Compare using anova() and set the test to Chisq (), anova(m1, m2, tets = “Chisq). Which variables should you keep and how did you determine this?

\*remember that lines()follows the order of x and y coordinates you give it.