HMMA 307 : Modèles linéaires avancés

Linear mixed effects models

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https://github.com/cassandrelepercque/HMMA_307-Project

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Linear mixed effect models

Matrix model equation

$$y = X\beta + Zu + \epsilon$$

where,

- y is a known vector of observations, with mean $\mathbb{E}[y] = X\beta$,
- β is an unknown vector of fixed effects,
- u is an unknown vector of random effects, with mean $\mathbb{E}[u] = 0$,
- ϵ is an unknown vector of random errors, with mean $\mathbb{E}[\epsilon] = 0$,
- X and Z are known design matrices relating the observations y to β and u, respectively.

Presentation of the dataset

Does the trophic position of fish increase with their size ?

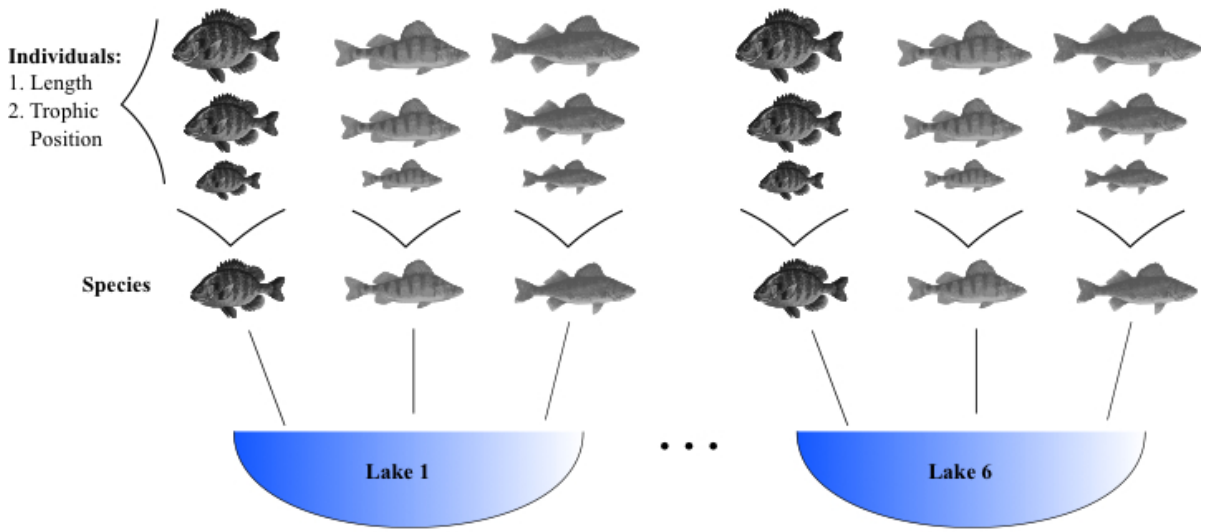

Figure: Dataset : Fish trophic position

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Model

The a priori model

$$TP_{ijk} \sim Length_i + Lake_j + Species_k + \epsilon$$

- TP_{ijk} is the trophic position of individual i from lake j of species k,
- ϵ are the residuals of the model.

Boxplot 1

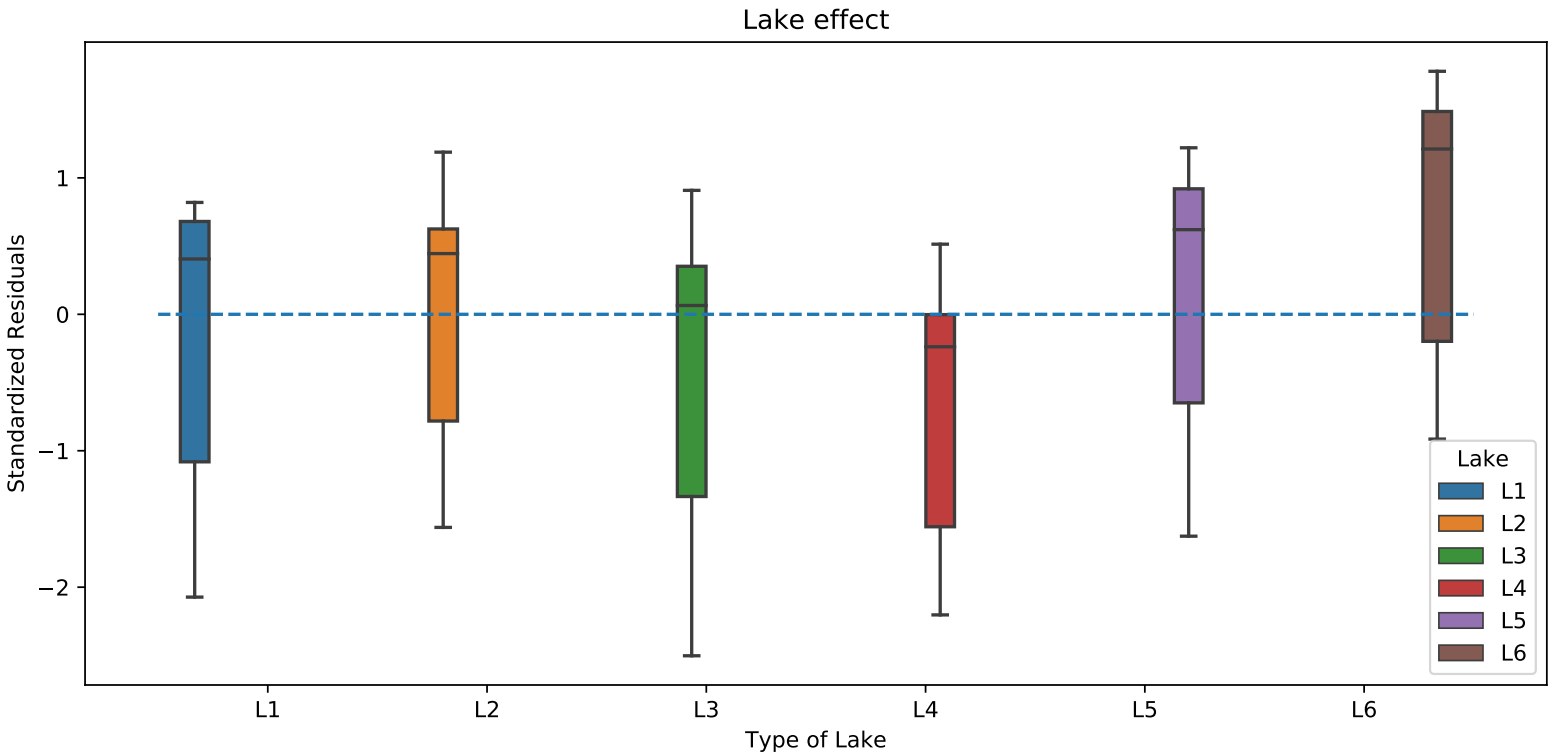

Figure: Boxplot of the lake effect

Boxplot 2

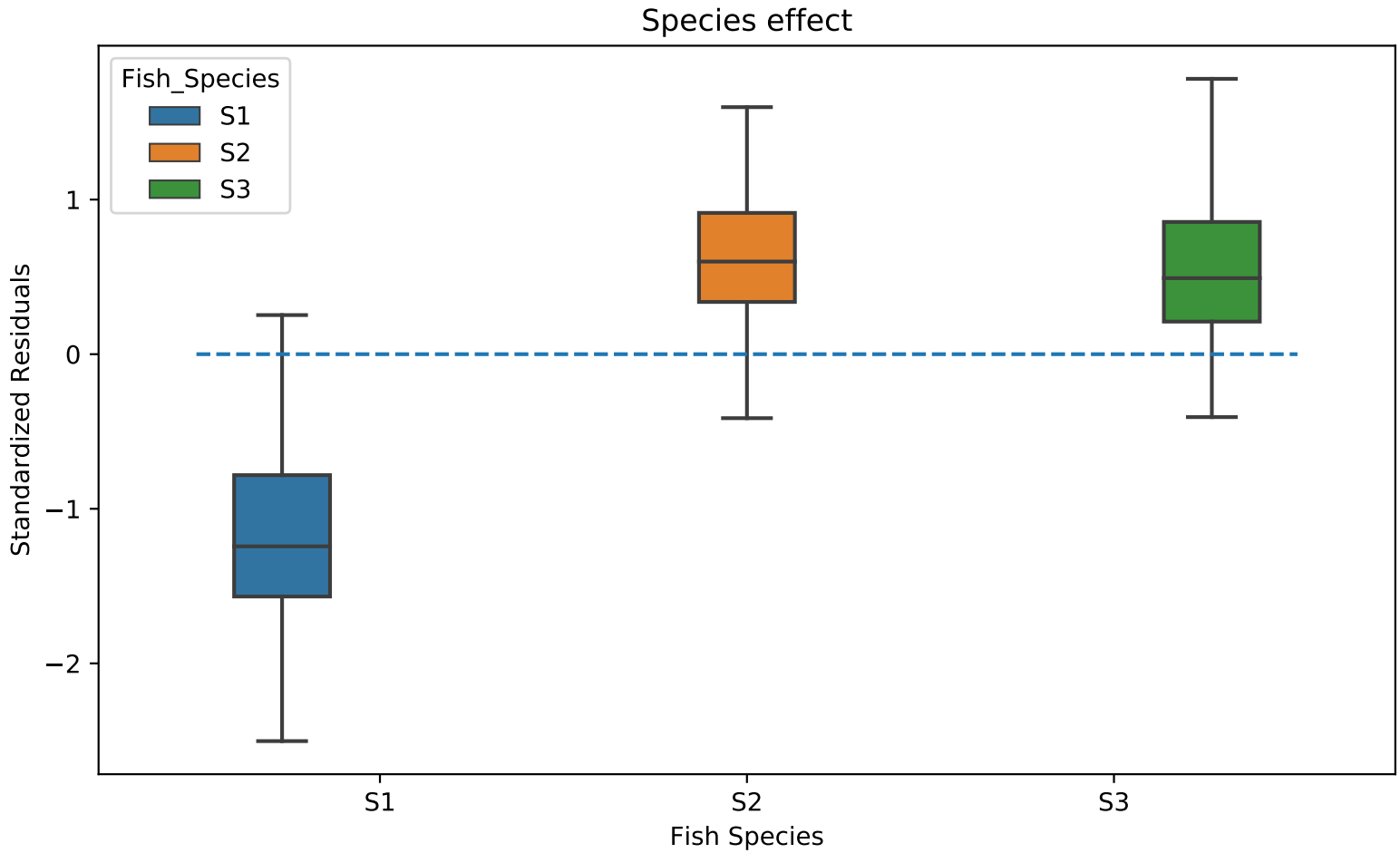

Figure: Boxplot of the fish species effect

The potential models

- **Model 1:** Linear model without random effect,
- **Model 2:** Complete model with different intercepts,
- **Model 3:** Complete model with differents intercepts and slopes,
- **Model 4:** No Lake effect, random intercept only,
- **Model 5:** No Species effect, random intercept only
- **Model 6:** No Lake effect, random intercept and slope,
- **Model 7:** No Species effect, random intercept and slope,
- **Model 8:** Complete model with intercepts and slopes varying by lake,
- **Model 9:** Complete model with intercepts and slopes varying by species.

AIC Comparison

Akaike information criterion

$$AIC = deviance + 2 \times (p + 1)$$

Where,

- $deviance = -2 \times (loglikelihood)$,
- $p =$ number of parameters.

AIC Comparison

Models	M1	M2	M3	M4	M5
AIC	480.726	113.490	69.178	280.069	460.434

Models	M6	M7	M8	M9
AIC	270.557	462.406	125.754	64.757

Table: AIC of each model.

Model validation: Homogeneity

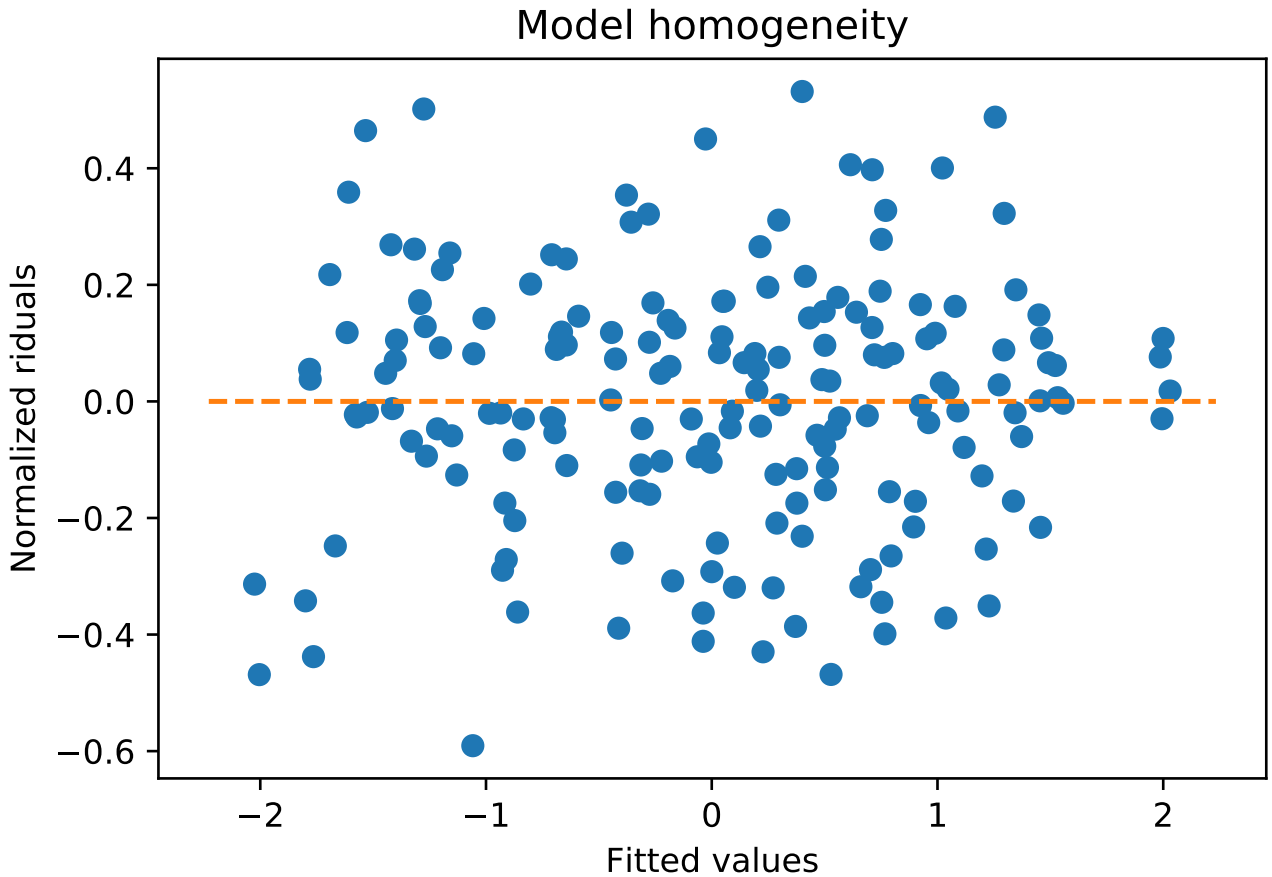

Figure: Homogeneity

Model validation: Independence

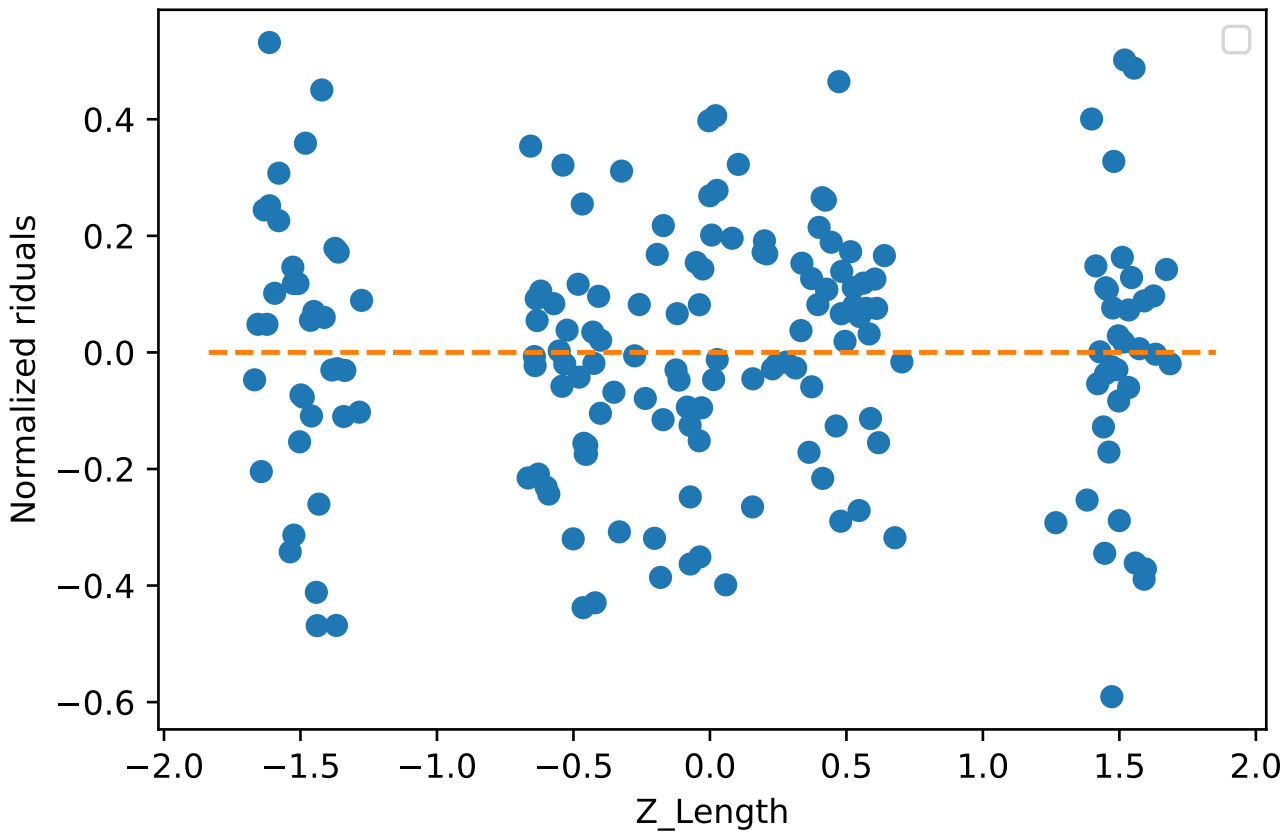

Figure: Independence

Model validation: Independence

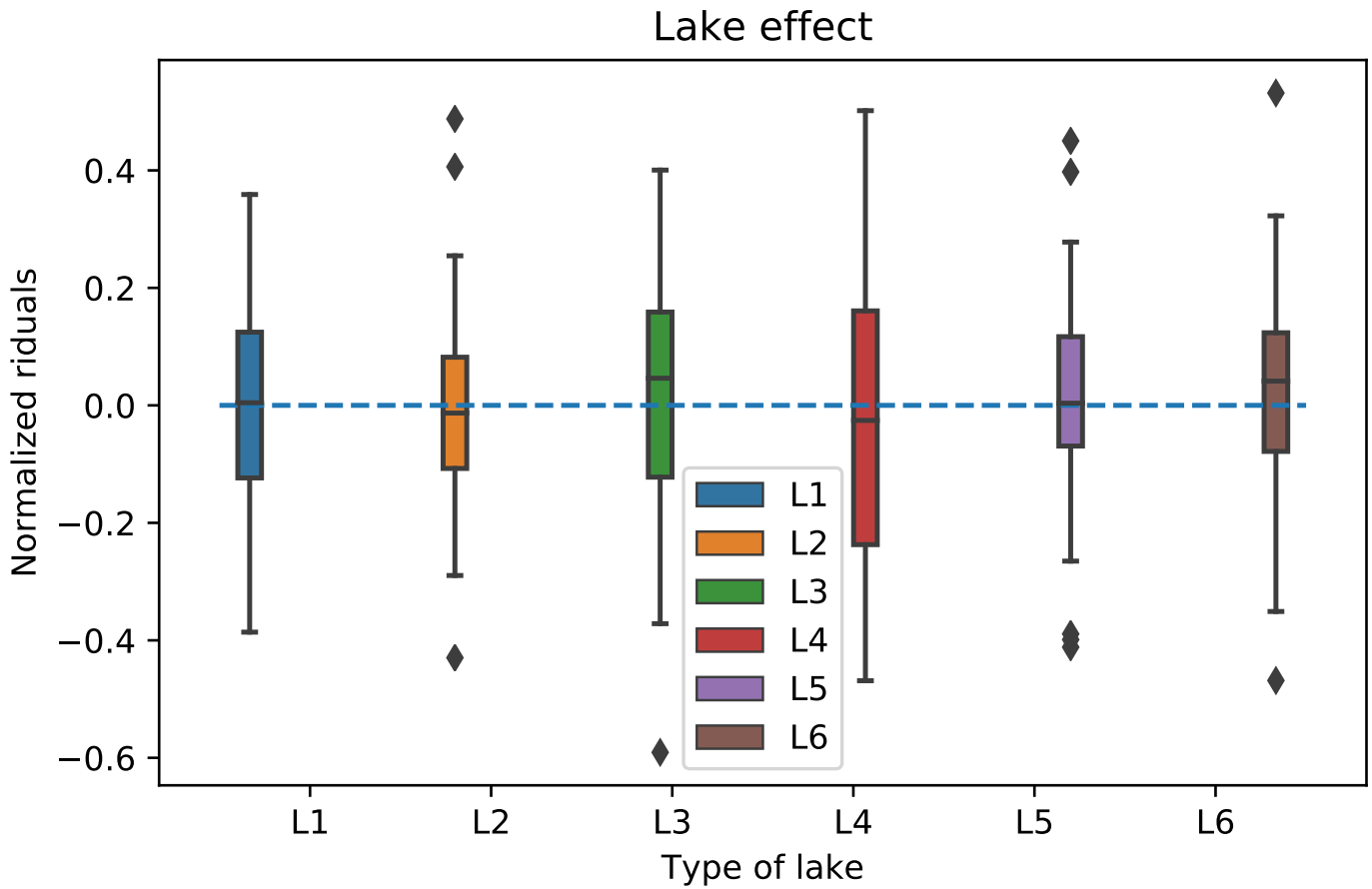

Figure: Independence

Model validation: Independence

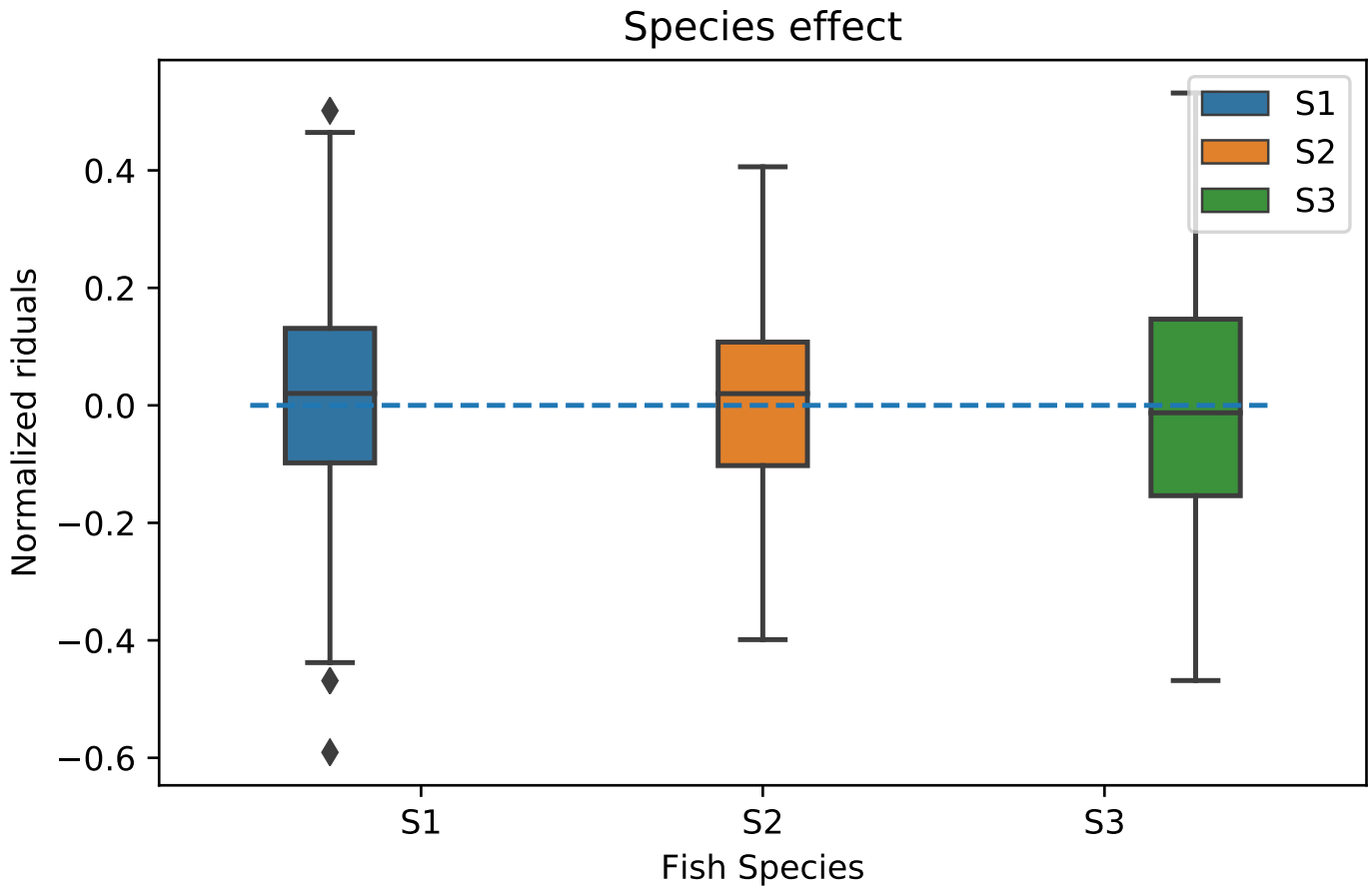

Figure: Independence

Model validation: Normality

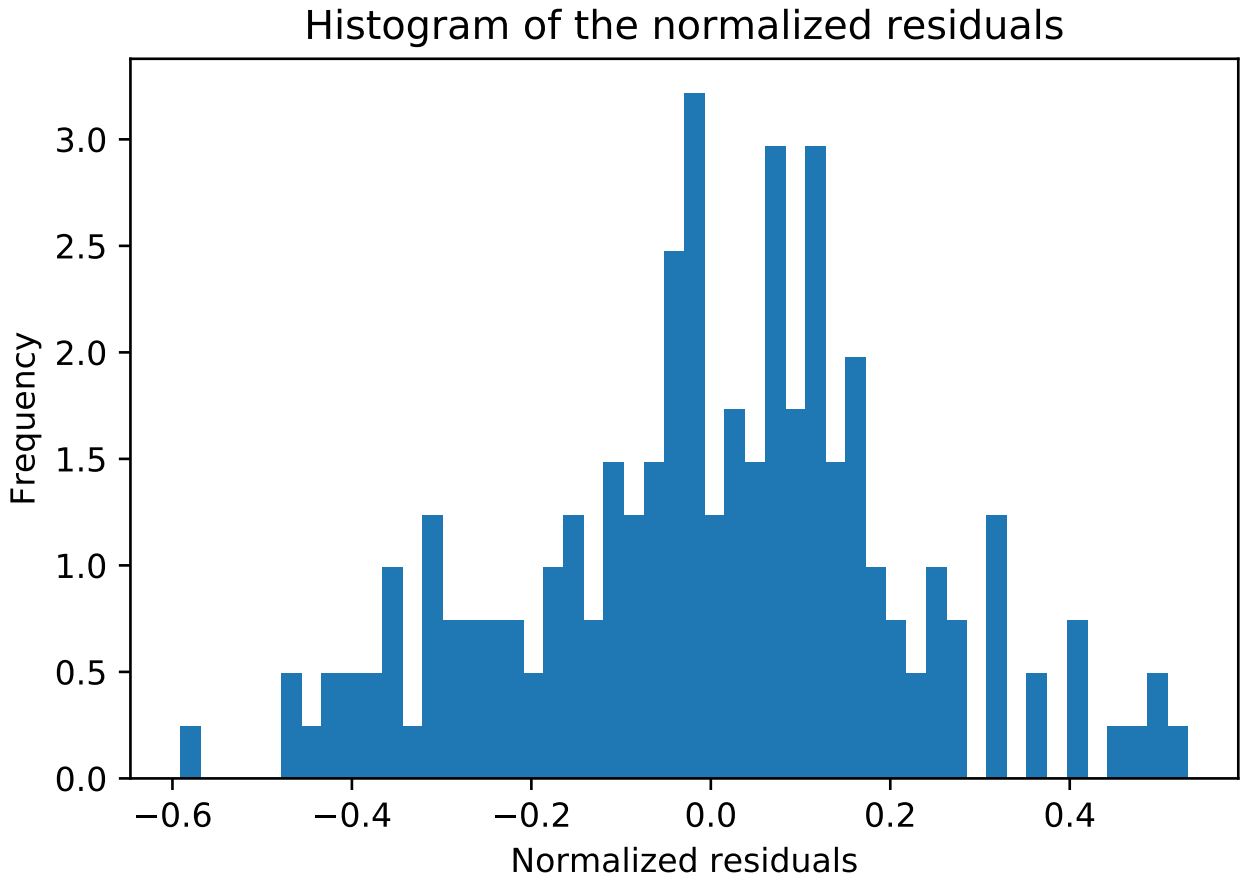

Figure: Normality

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Conclusion

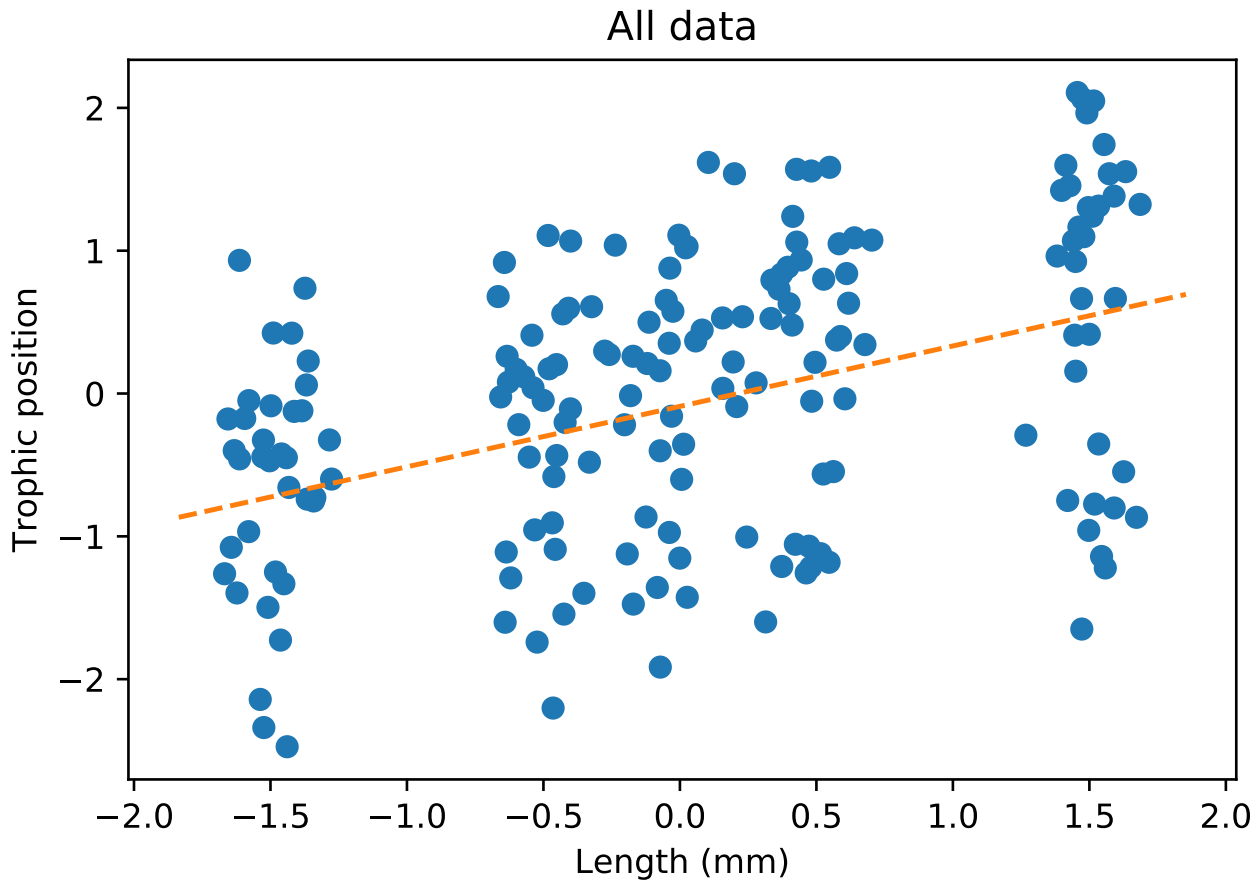

Figure: All data visualization

In our case, the trophic position increases with the size of the fish.

Conclusion

Mixed models are really good at accounting for variation in ecological data while not loosing too many degrees of freedom.