Identifying Thresholds of Quality in Early Child Care and Education: A Non-Parametric Approach

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Overview

- Background
- Data Sources
- Analytic Approaches
  - General Additive Modeling
  - Spline Analyses
  - Framework for this project
- Examples
- Summary

Background

- Led by CYFS Faculty Affiliates
  - Julia Torquati
  - Helen Raikes
- Substantively speaking…
  - Evidence that better quality generally predicts more optimal child outcomes

Aims

- **Aim 1**: To determine whether there are ***specific thresholds*** of quality that predict children's developmental outcomes
- **Aim 2**: To determine whether thresholds of quality vary as a function of:
  - (1) age of child in child care;
  - (2) ethnicity of teacher/provider;
  - (3) ethnic match/mismatch of teacher/provider and child;
  - (4) income level of child

Background

- Linear vs. Non-Linear models
  - Linear the norm
    - Implies relationship same across all points
  - Non-linear are necessary
    - The strength of association between predictors and outcomes varies across the measurement scale such that particular levels of quality are significantly more strongly associated with children's development.

Early Head Start Sample

	Family Child Care	Center Care
14 months	151	372
24 months	159	416
36 months	134	500
60 months	80	1043

QUINCE Sample

- Children ages 20 months – 5 years
- Assessed fall and spring
  - T2 focus of this analysis

Family Child Care	Center Care
650	652

Analytic Approaches

- General Additive Modeling
  - Empirically driven
  - Non-parametric approach
  - Identify relationship between variables
    - Linear vs. Non-linear
  - Identify possible thresholds
    - Based on shape of observed relationship

Analytic Approaches

- Spline Models
  - Identify empirical thresholds obtained from GAM via the model comparison between linear and non-linear associations
  - Investigate the change of associations within each interval of quality of care classified by empirical thresholds
  - Predict associations based on the spline model

Introduction to GAM

- Generalized Additive Model (GAM)
  - Each term is estimated using a univariate smoother
  - The estimate explains how the dependent variable changes with the corresponding independent variables

$$\eta = s_0 + \sum_{i=1}^{p} s_i(X_i)$$

where s_i are smooth functions defines the additive component.

- The smoothers are estimated by using the backfitting algorithm and the local scoring algorithm
  - The algorithms are implemented in PROC GAM in SAS and `gamm` package in R

Spline Analyses

- For identification of thresholds, the following two models are compared

$$\text{Linear model} \quad Y_i = \beta_0 + \beta_1 \cdot X_i + e_i$$

$$\text{Spline model} \quad Y_i = \beta_0 + \beta_1 \cdot X_i + \beta_2 \cdot T_i^1 + \beta_3 \cdot T_i^2 + e_i$$

- To investigate the effect of moderator, the following two models are compared

$$\text{Spline model} \quad Y_i = \beta_0 + \beta_1 \cdot X_i + \beta_2 \cdot T_i^1 + \beta_3 \cdot T_i^2 + e_i$$

$$\text{Model with Moderator} \quad Y_i = \beta_0 + \beta_1 \cdot X_i + \beta_2 \cdot T_i^1 + \beta_3 \cdot T_i^2 + \sum_{k=1}^{K} C_i^k + e_i$$

Framework for Identifying Thresholds

- Thresholds were identified
  - Empirically via GAM
  - Based on a priori research/knowledge

Example 1

- Begin by implement GAM approach
  - Non-parametric approach to investigating the relationship between quality measures of child care (ITERS or ECERS, FDCRS, and CIS) and child outcomes
- Want to determine:
  - Relationship linear or non-linear?
  - If non-linear, are thresholds implied?

Example 1

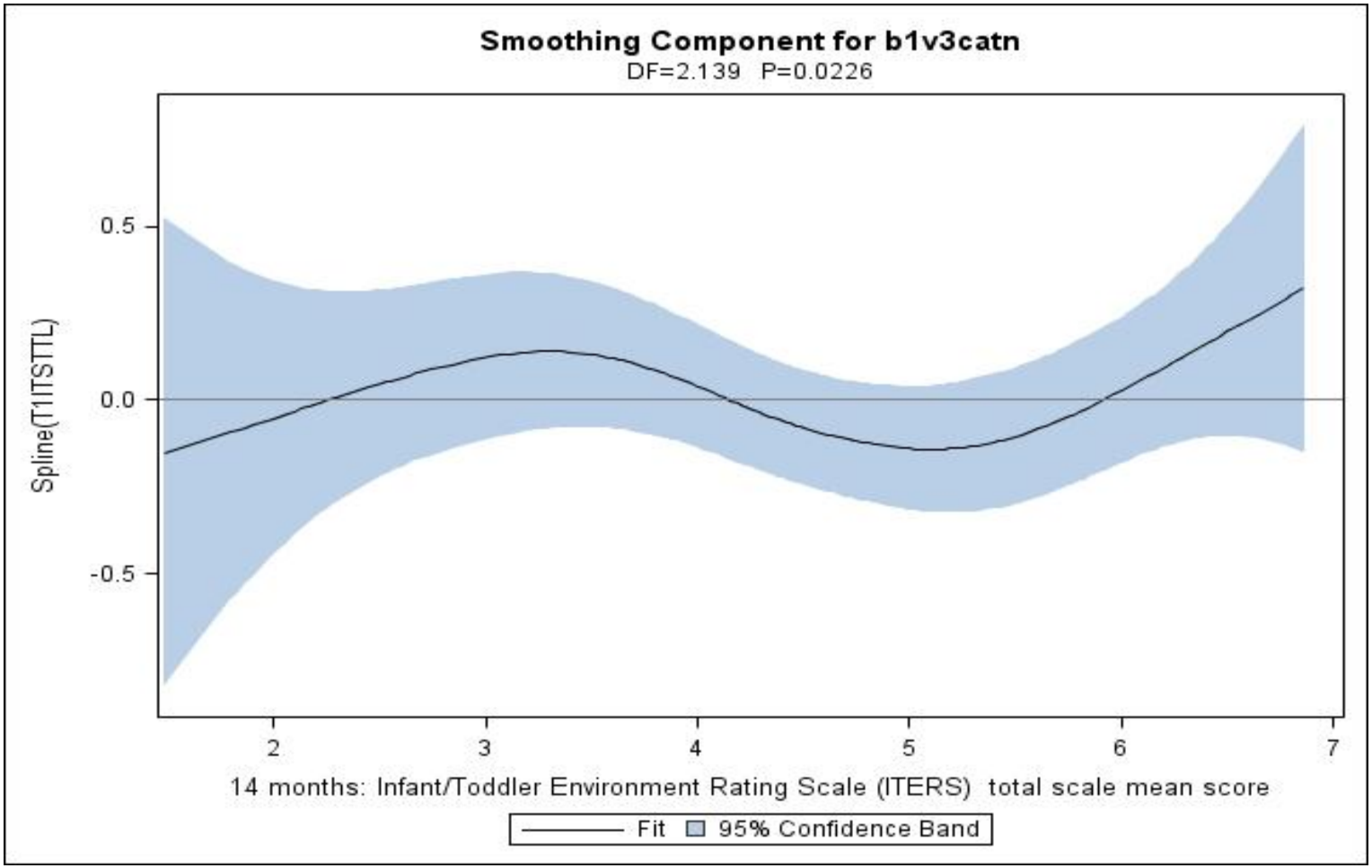
- To examine the relationship between ITERS quality measure and sustained attention outcome measure at 14 month in the EHS sample
- Using PROC GAM in SAS

```
proc gam  data=Jihoon.ehs   plots=components(clm);
          model  b1v3catn = spline(T1ITSTTL)/
                    anodev = refit   method = gcv   epsscore = 1e-6;
          output  out = ehs14 p;
run;
```

- It produces parameter estimates, estimated degree of freedom, and smoothing plot(s)

Example 1 – GAM Plot

- ITERS and Sustained Attention



Example 1 – SAS Output

The GAM Procedure
Dependent Variable: b1v3catn
Smoothing Model Component(s): spline(T1ITSTTL)

Summary of Input Data Set

Number of Observations	335
Number of Missing Observations	2666
Distribution	Gaussian
Link Function	Identity

Regression Model Analysis
Parameter Estimates

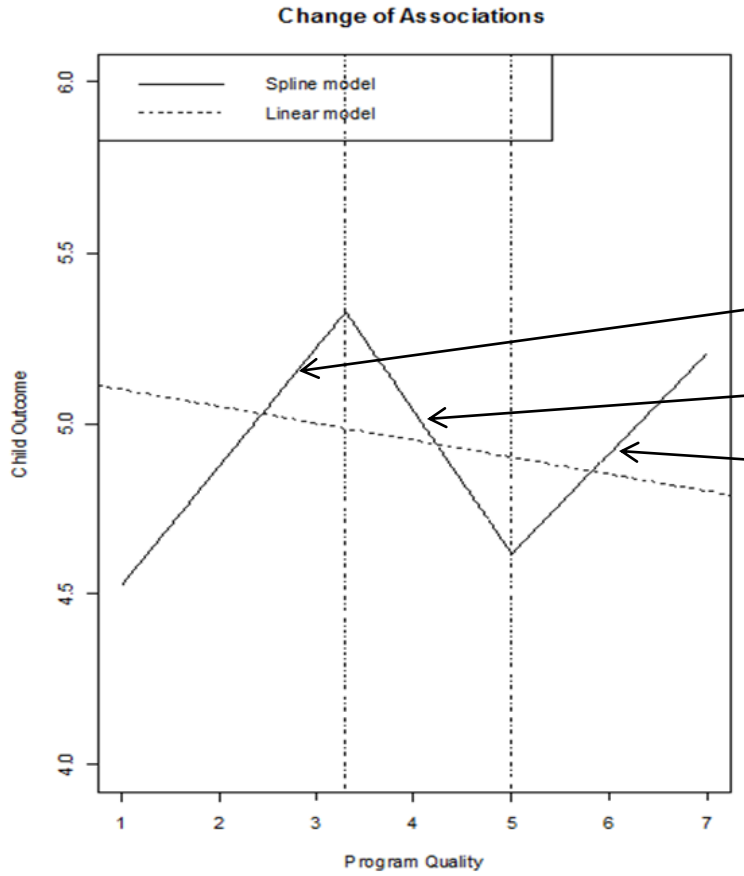
Parameter	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	5.15073	0.21544	23.91	<.0001
Linear(T1ITSTTL)	***-0.04984***	***0.04601***	***-1.08***	***0.2795***

Smoothing Model Analysis
Analysis of Deviance

Source	DF	Sum of Squares	Chi-Square	Pr > ChiSq
Spline(T1ITSTTL)	***2.13902***	***8.274623***	***7.8755***	***0.0226***

Example 1 – Spline Result

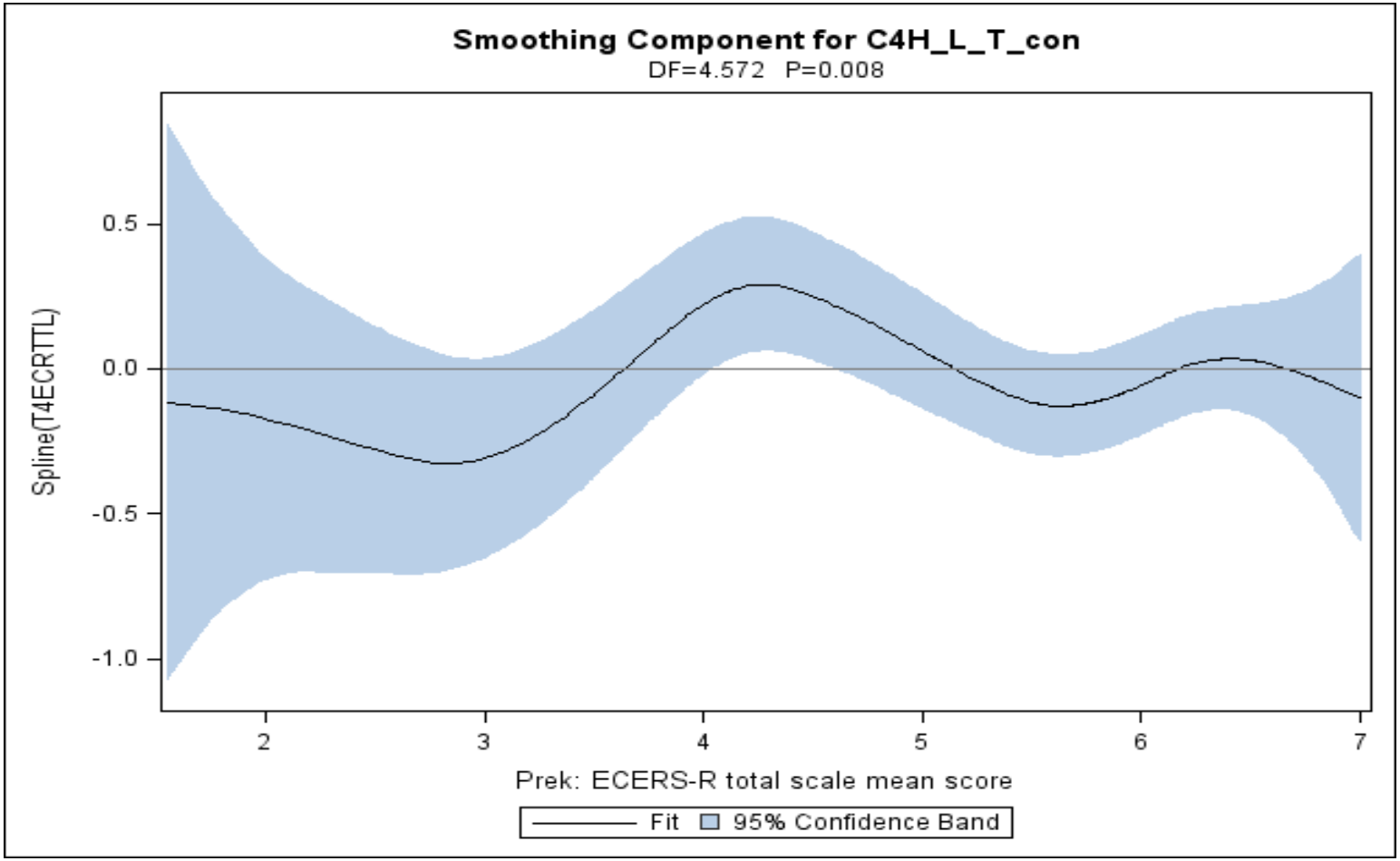
- Testing empirical thresholds - 3.3 and 5.0
  - F2=4.628; p-value=0.010



Line Segment	Estimate (slope)	Std Err	P-value
[0.0, 3.3]	0.35 (0.35)	0.219	0.111
[3.3, 5.0]	-0.767 (-0.417)	0.316	0.016*
[5.0, 7.0]	0.712 (0.295)	0.238	0.003**

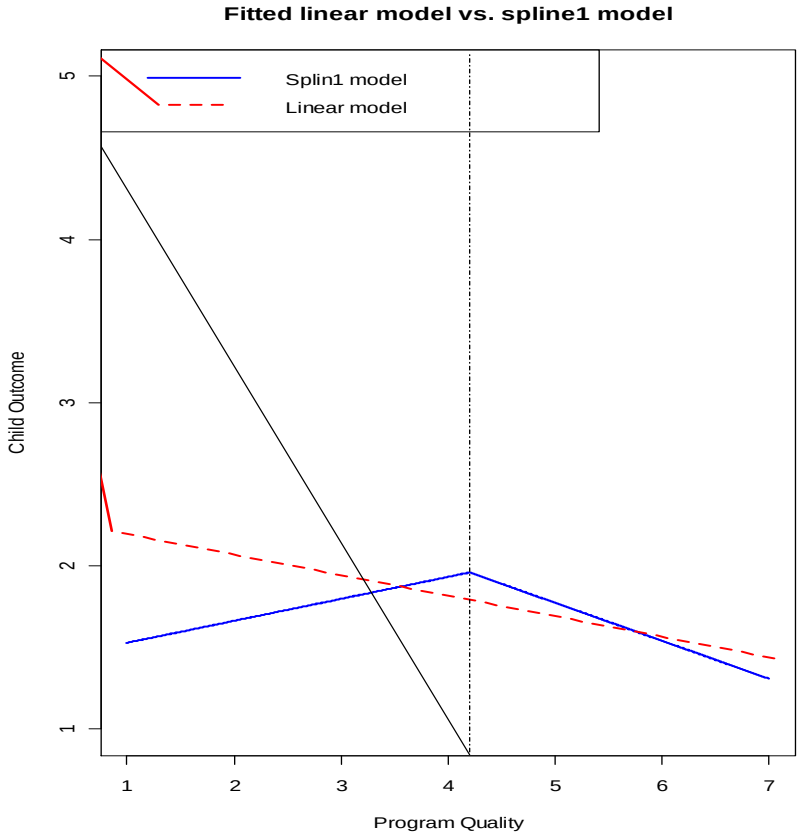
Example 2 – GAM Plot

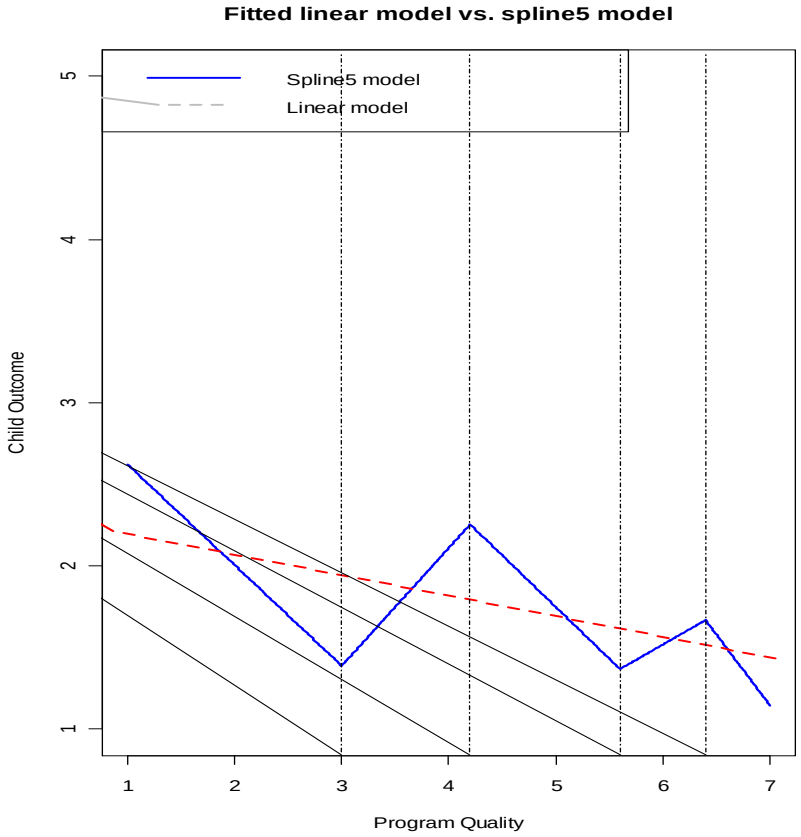
- ECERS-R and Howes Ladd conflict with teacher rating



Example 2 – Spline Results

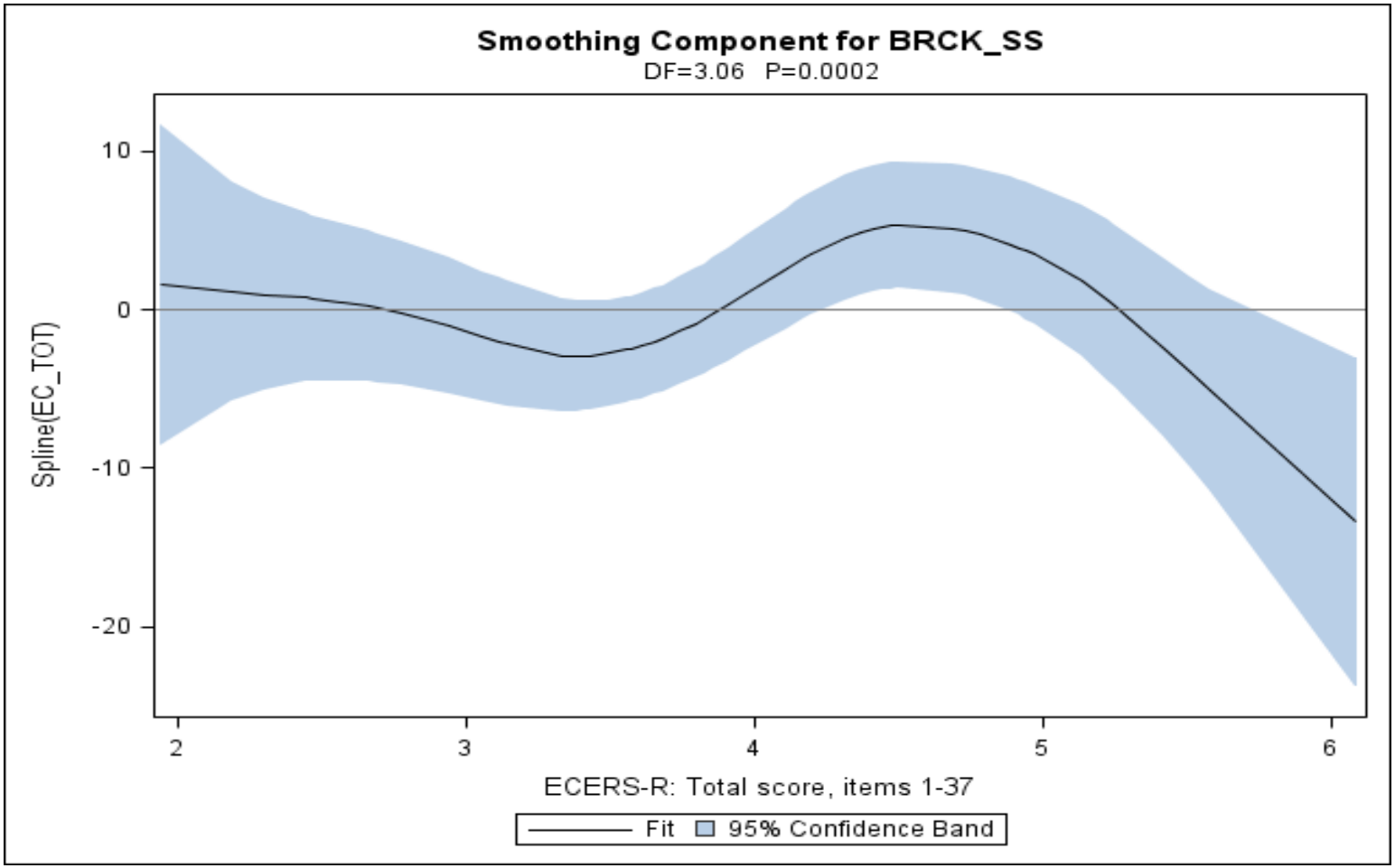
- Comparing possible models
- Practical?





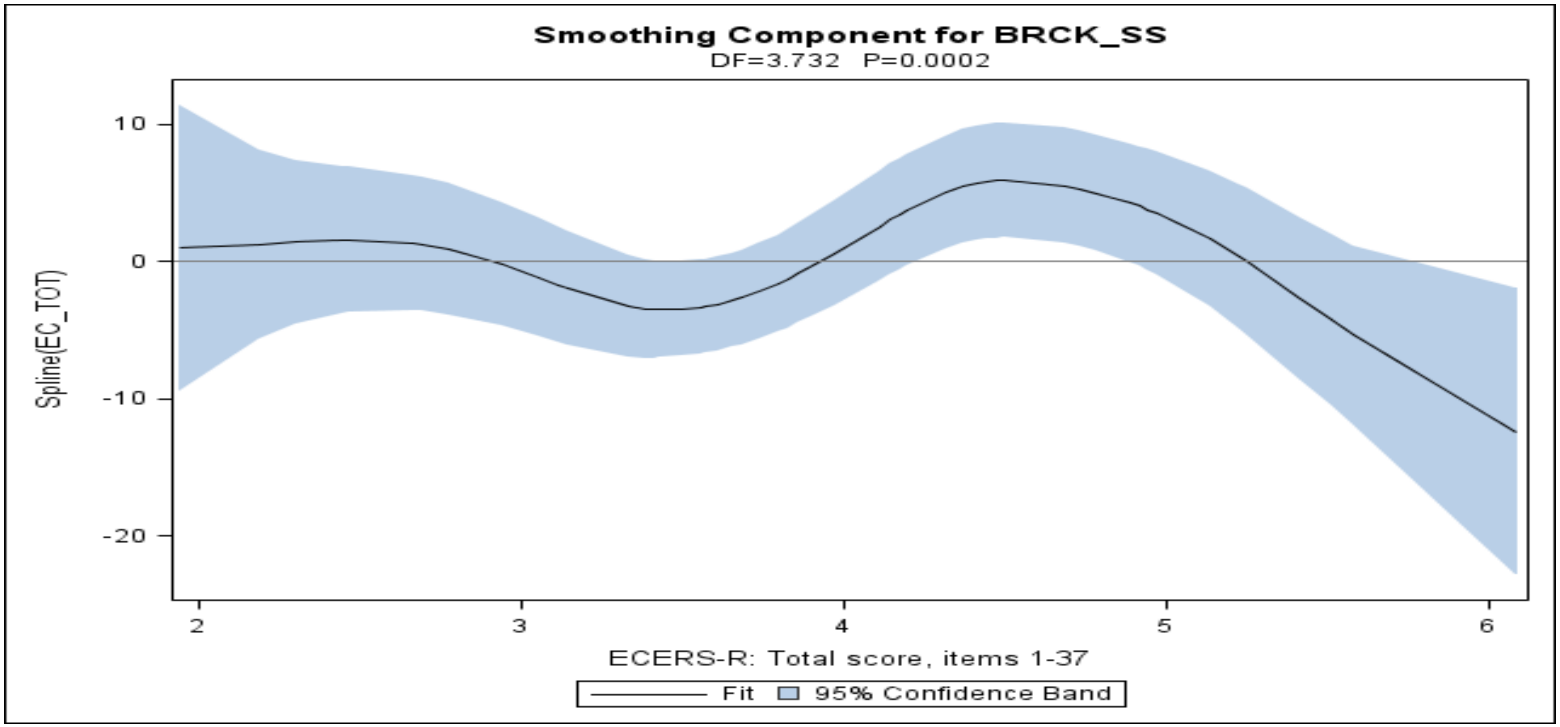
Example 3 – GAM Plot

- Bracken school readiness and ECERS-R



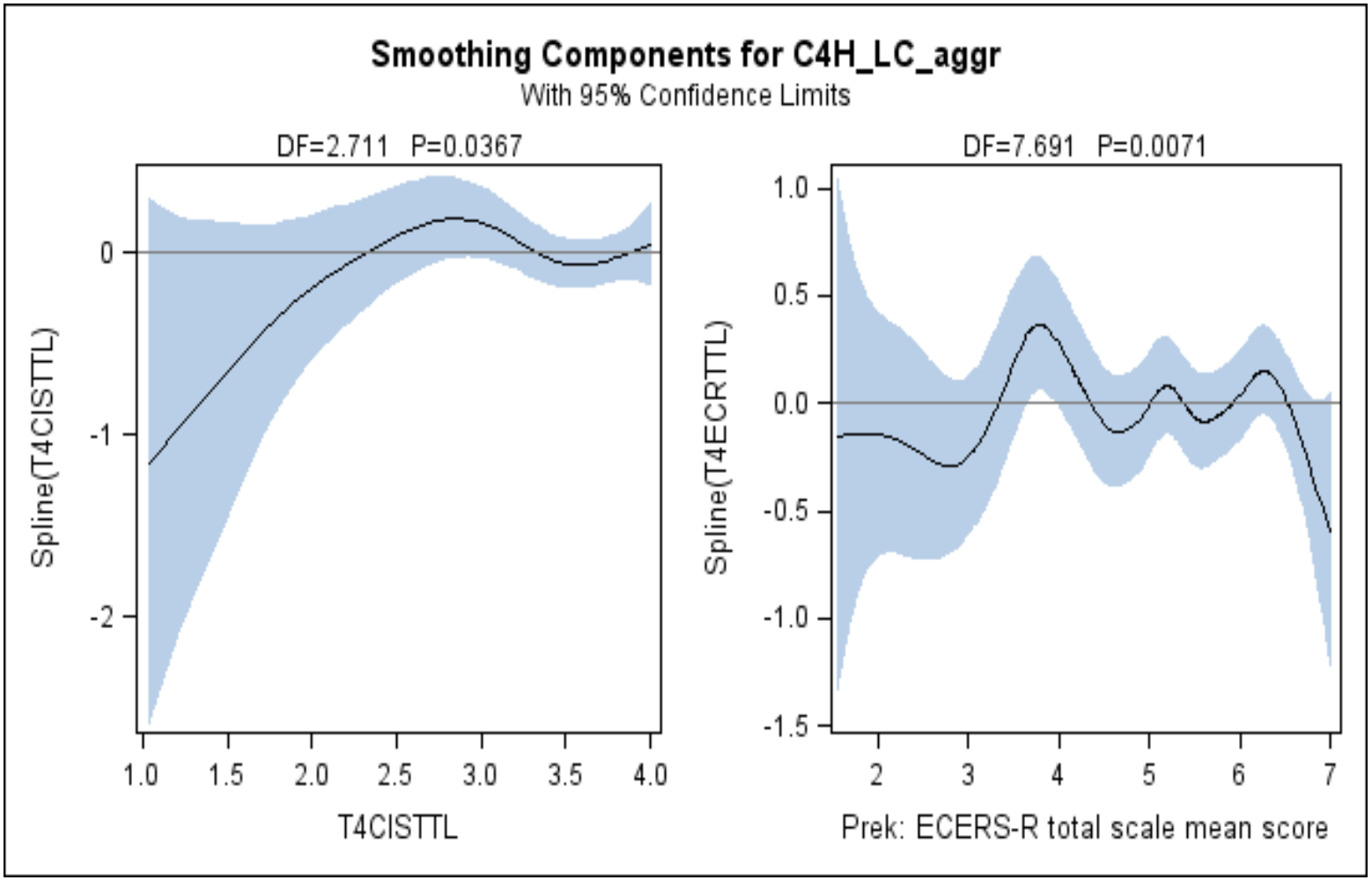
Example 3 – GAM Plot

- Bracken school readiness and ECERS-R
  - by Gender
- Gender significant (p-value=0.0002)
  - Does not significantly impact GAM result



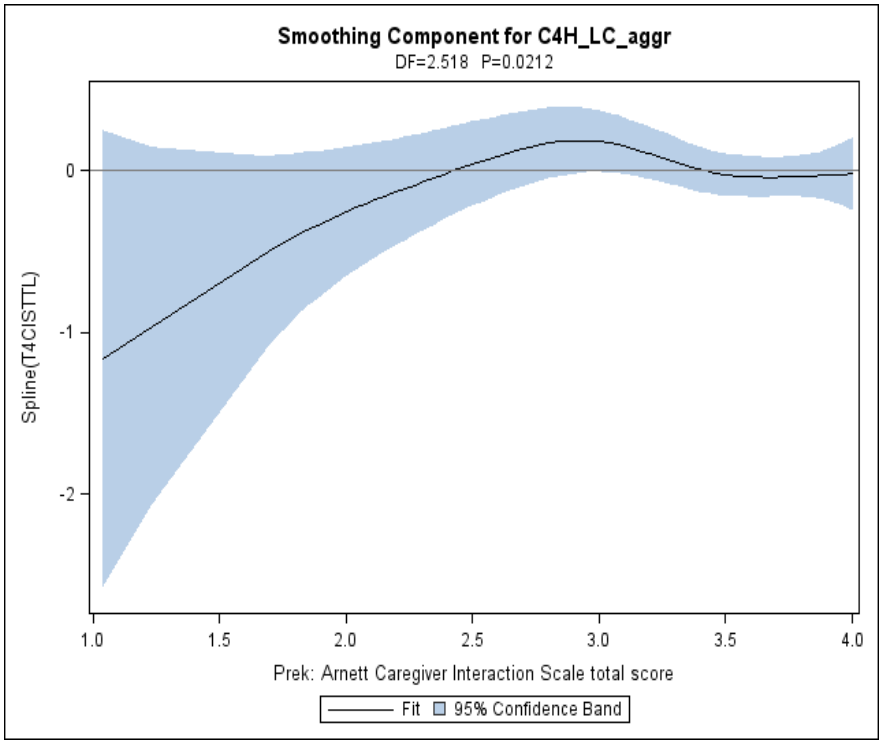
Example 4 – GAM Plots

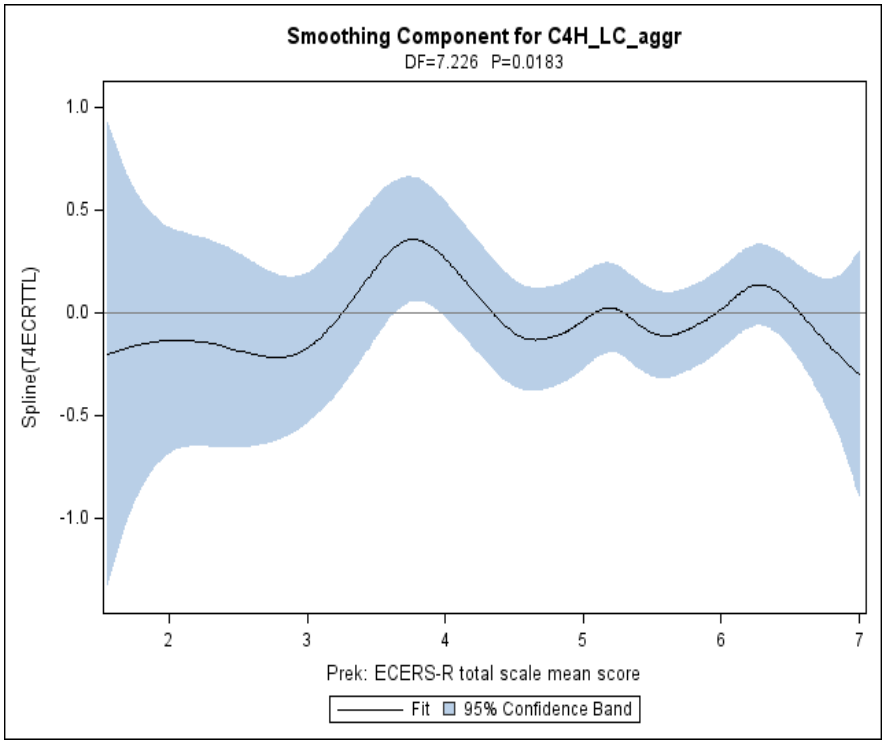
- ECERS-R & CIS and Howes Ladd aggressive composite



Example 4 – GAM Plots

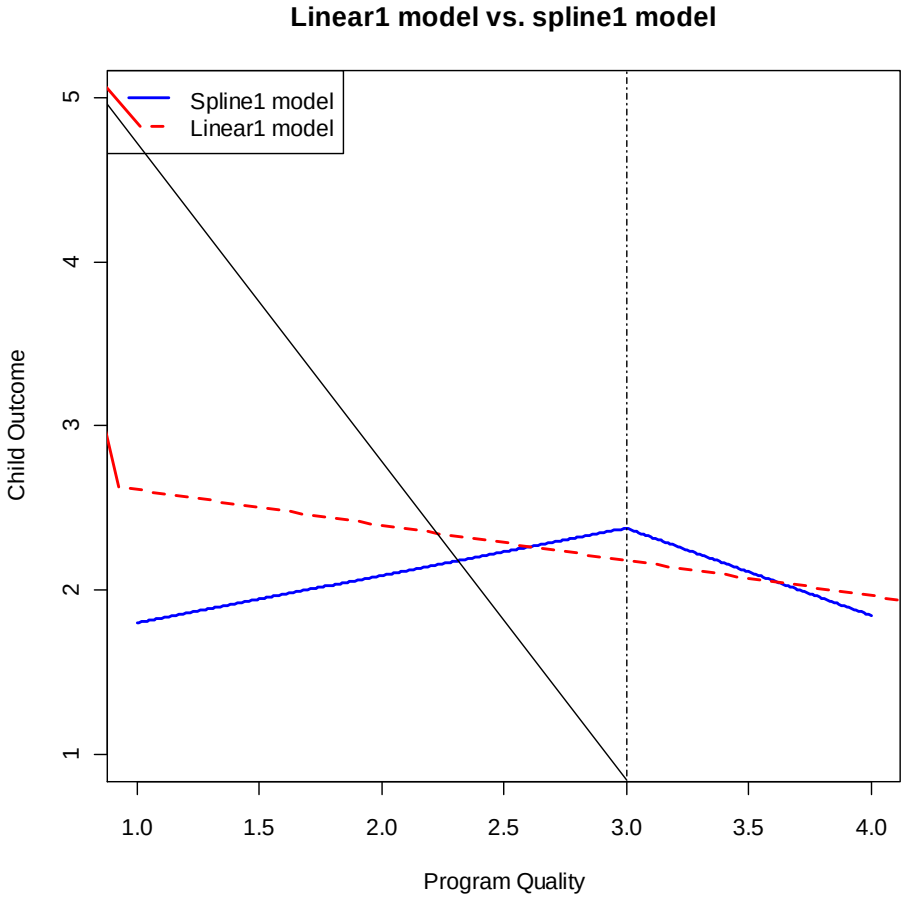
- What if we look at the relationships separately?
  - The results are almost identical, which is a property of GAM

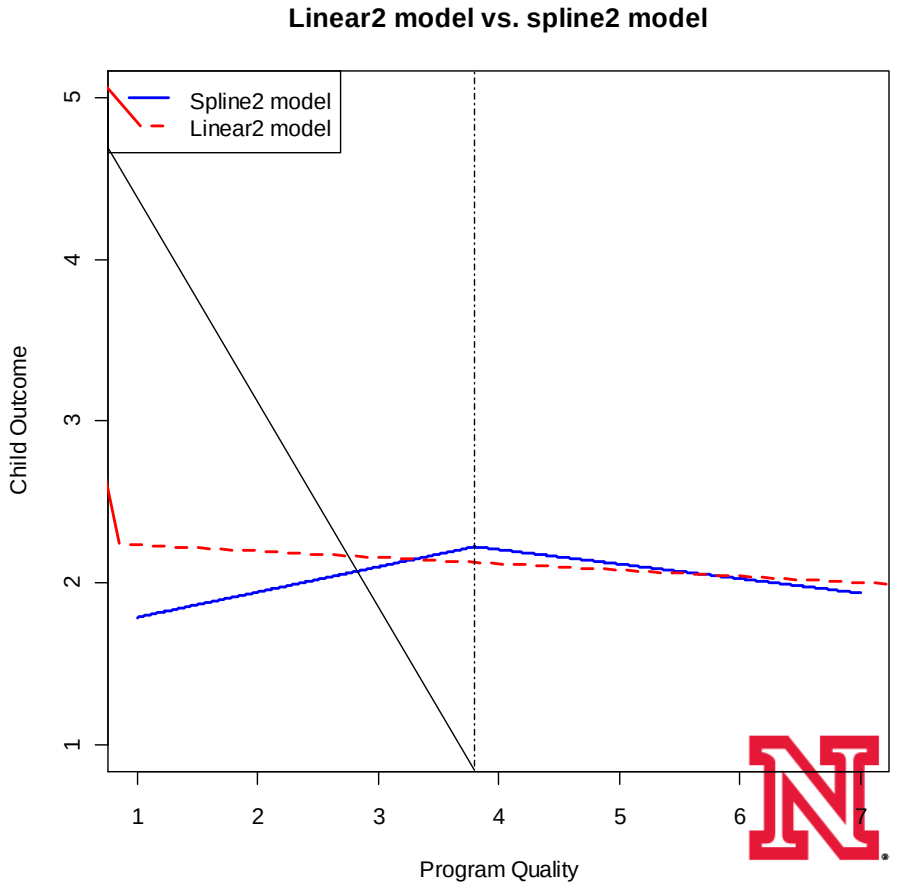




Example 4 – Spline Results

- Compare the spline model with the suggested thresholds with a linear model on both cases





Utility of the Approaches

- GAM excellent approach to identifying thresholds
  - No a priori knowledge necessary
    - Can be useful though
  - Does not provide for inferential statements
- Spline
  - Can use a priori and/or empirical information
  - Can make inferential statements

Thank You!

Questions?

For Additional Questions/Information

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