Applying Polynomial Regression to Dyadic Data

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Objectives

The overall theme of this poster will be polynomial regression. The main idea is to explore polynomial regression on a set of dyadic data.

Introduction

Dyadic data:

- Used by family researchers who are interested in comparing the attitudes, behaviors, and opinions of pairs
- Inter-individual reporting (e.g. comparison of husband's report of their support toward his wife to the wife's report of their support towards the husband)
- Intra-individual reporting (e.g. comparison of an observer's report of husband's hostility to an observer's report of the wife's hostility)

Difference scores are often used to analyze dyadic data, but we'll present an alternative to this called polynomial regression.

Difference Scores

- Difference scores are used to see how well two variables or indices 'fit' together. Some examples of difference scores are:

$$Z = \beta_0 + \beta_1(X - Y) + \epsilon$$
$$Z = \beta_0 + \beta_1|X - Y| + \epsilon$$
$$Z = \beta_0 + \beta_1(X - Y)^2 + \epsilon$$

- There are some big issues with difference scores:
  - The most important reason to avoid using difference scores is that it makes it difficult to identify the underlying mechanism
  - Assumptions: the difference between two entities to the outcome variable are assumed to be symmetric and that the outcome is constant at all points where the two entities are equal

What is polynomial regression?

Edwards and Parry suggested Polynomial Regression (Edwards and Parry 1993) as an alternative to difference scores.

- Take the Squared Difference and expand it

$$(X - Y)^2 = X^2 + Y^2 - 2XY$$

- This leads to using a quadratic regression model

$$Z = \beta_0 + \beta_1 X + \beta_2 Y + \beta_3 X^2 + \beta_4 Y^2 + \beta_5 XY + \epsilon$$

When looking at the quadratic regression model, we are concerned with three key elements:

1. Stationary Point: Points where the slope is zero no matter which direction you take the derivative
2. Principal Axis: Measure the amount of "bend" in two directions at the stationary points
3. Predicted Surface: a 3D-surface that allows us to view the predicted response

Data

Here is some background on data used in this project:

- Interested in understanding the congruence between survey reports and observer reports
- Comes from the Iowa Midlife Transitions Project (MTP); this longitudinal study conducted between 1991 and 2001 on families from eight counties in rural Iowa
- Study was designed to look at the effects of the 1960's farm crisis on rural Midwestern families
- Families in MTP either participated in the Iowa Youth and Families Project (IFYP) or the Iowa Single Parent Project (ISPP)

These are the variables of interest:

Z : Obs RQ of couple i: $1 - 9$
Y_2 : Wife(i)'s Report of RI: $1 - 4$
X_2 : Husband(i)'s Report of RI: $1 - 4$

Results

The fitted quadratic polynomial using perceived relationship instability as a predictor for relationship quality is:

$$\hat{z} = -0.52 + 0.25x + 0.23y + 0.02x^2 + 0.09xy + 0.37y^2$$

Stationary points are at $(-10.19, 0.92)$
Likewise we can look at the principal axes:

$$y = 82.92 + 8.05x$$
$$y = -0.34 - 0.12x$$

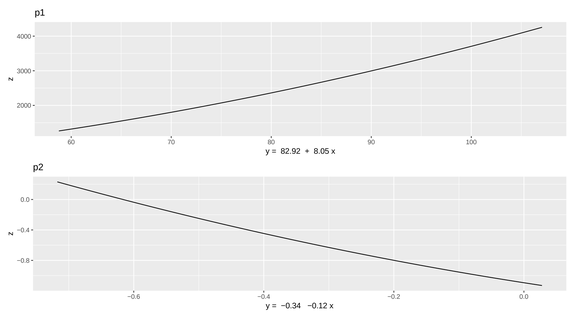

Figure: This Figure shows slices of the response surface taken at the two principal axes.

Here are some screenshots of our predicted surface:

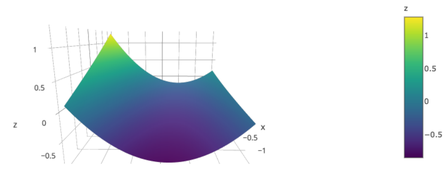

Figure: Predicted surface plot from the center perspective.

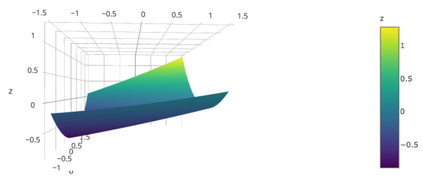

Figure: Predicted surface plot from the y axis perspective i.e. eliminating the x axis.

Conclusion

Pros:

- Easily visualize the realm of possible combinations of the predictor variables and their effect on the predicted response
- Helps identify the underlying mechanism by seeing how different predictors affect the surface

Cons:

- Not super intuitive interpretations of model components
- Issues with data greatly affect inferences e.g. our variables were skewed heavily

References

[1] R Core Team.
R: A Language and Environment for Statistical Computing.
R Foundation for Statistical Computing, Vienna, Austria, 2014.

[2] Jeffrey R. Edwards.
Problems with the use of profile similarity indices in the study of congruence in organizational research.
Personnel Psychology, 46:641–665, 1993.

[3] Jeffrey R. Edwards.
On the use of polynomial regression equations as an alternative to difference scores in organizational research.
Academy of Management Journal, 36(6):1577–1613, 1993.

[4] L. Alison Phillips.
Congruence research in behavioral medicine: methodological review and demonstration of alternative methodology.
Journal of Behavioral Medicine, 36(1):61–74, 2012.

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