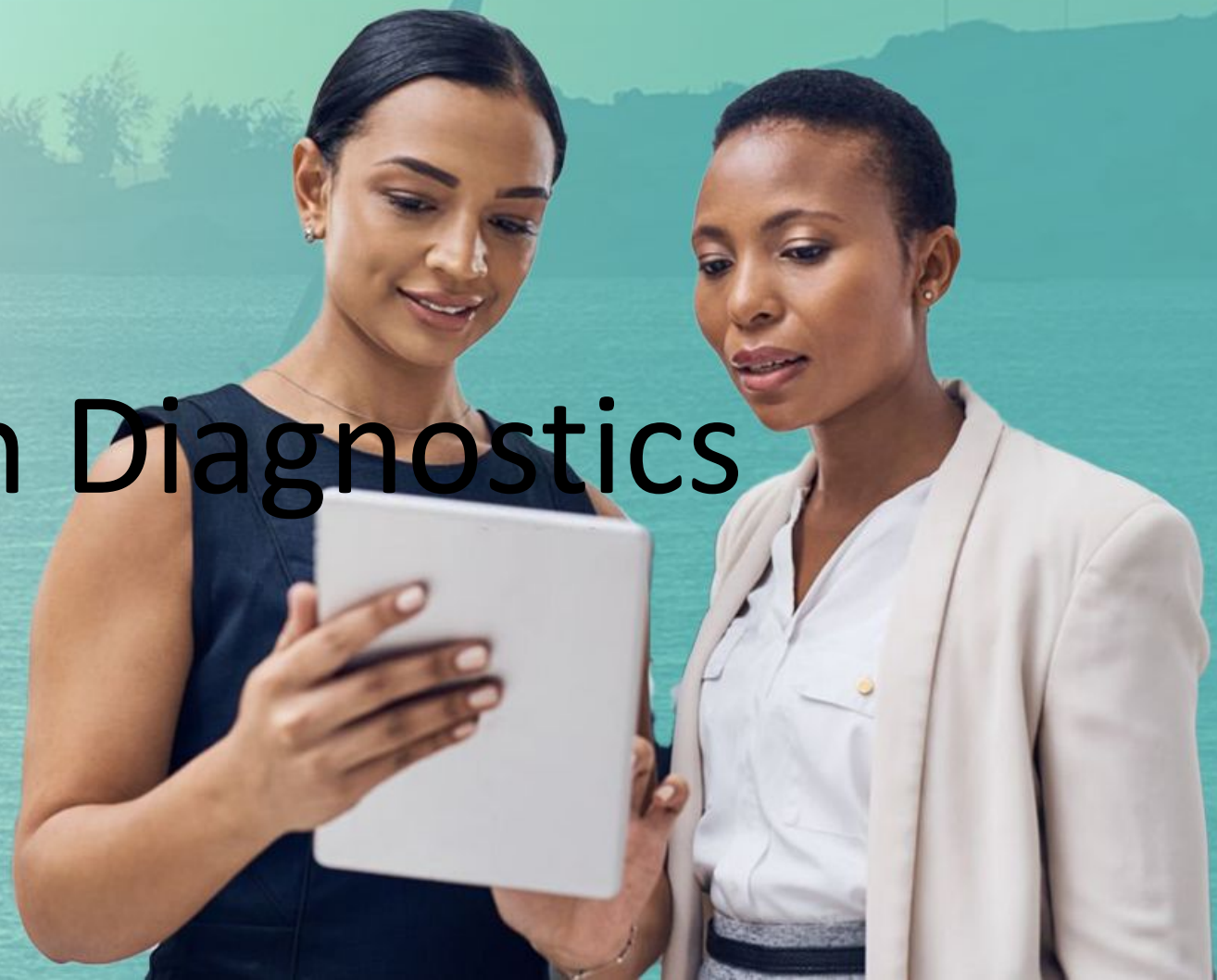
Indepth Research Institute

Transforming People and Organizations in Africa Since 2003



Regression Diagnostics

Linear Regression Assumptions- explored in this class

Linearity – the relationships between the predictors and the outcome variable should be linear

Normality – the errors should be normally distributed – technically normality is necessary only for hypothesis tests to be valid, estimation of the coefficients only requires that the errors be identically and independently distributed

Homogeneity of variance (homoscedasticity) – the error variance should be constant

Independence – the errors associated with one observation are not correlated with the errors of any other observation

Normality

```
// Visual checks
kdensity r, normal      // Kernel density with normal overlay
pnorm r                 // P-P plot
qnorm r                 // Q-Q plot

// Formal tests
swilk r                 // Shapiro-Wilk test
```

Normality Corrective actions

Model Specification

- Ensure model is correctly specified.
- Add or drop variables and interaction terms as needed.

Check Regression Assumptions

- Verify that all assumptions are met, as one violation can affect others.

Assess Non-Normality

- Examine residuals' shape using a Q-Q plot.

Apply appropriate corrections if non-normality persists.

- Consider Transformation Drawbacks
- Transformed outcomes require back-transformation for interpretability.

Re-check Assumptions Post-Correction

- After adjustments, reassess all assumptions.

Normality Corrective actions by shape

Skew Adjustments

Moderate Positive: Use $\sqrt{}$(y + constant), Substantial Positive: Use log(y + constant), Severe Positive: Use 1/(y + constant), Negative Skew: Use similar transformations with (constant - y)

Alternative: Try a Box-Cox transformation

Multiple Peaks: Add a categorical variable

Fat/Thin Tails - For asymmetry: See skew adjustments, For fat tails: Use asinh(y)

Truncated/Censored Data - Fit a special model (e.g., Heckman or beta)

Discrete Outcomes - Use a generalized linear model (e.g., logit, Poisson)

Heteroscedasticity

```
// Visual check
rvfplot, yline(0)

// Formal tests
estat hettest        // Breusch-Pagan test
whitetst             // White's test
```

Heteroscedasticity Corrective actions

- Check the other regression assumptions, since a violation of one can lead to a violation of another.
- Modify the model formula by adding or dropping variables or interaction terms.
- Fit a generalized linear model.
- Instead of ordinary least squares regression, use weighted least squares.

Multicollinearity Diagnostics

```
// After regression
vif                    // Variance Inflation Factors
// VIF > 10 indicates problematic collinearity

// More detailed collinearity diagnostics
collin x1 x2 x3
```

Multicollinearity corrective

Combine predictors

drop predictors

Non-linearity assessment

```
// Component-plus-residual plots
acprplot x1, lowess    // With lowess smoothing
cprplot x1, lowess     // Alternative visualization
```

Non-linearity corrective actions

Check the other regression assumptions, since a violation of one can lead to a violation of another.

Modify the model formula by adding or dropping variables or interaction terms.

Add polynomial terms to the model (squared, cubic, etc.).

Fit a generalized linear model.

Fit an instrumental variables model in order to account for the correlation of the predictors and residuals.

Resources

1. https://stats.oarc.ucla.edu/stata/webbooks/reg/chapter2/stata-webbooksregressionwith-statachapter-2-regression-diagnostics/
2. https://youtu.be/wXLFDTcPF84

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