

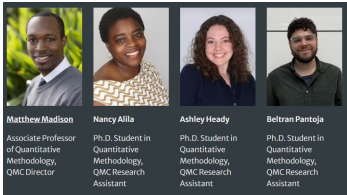
Path Models

A Quantitative Methods Consulting Center Workshop



Quantitative Methods Consulting Center (QMC)

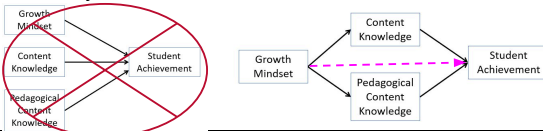
- QMC purpose is to provide quantitative research support and training for members of the MFECOE
- QMC Team



QMC Fall Methods Workshop Series

- "Basics of Measurement Modeling"
 - Introduction to *structural equation modeling* (SEM)
 - Slides and materials available at matthewmadison.com/workshop
- SEM is comprised of two foundational methods:

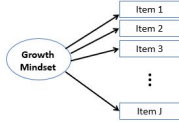
1. Path analysis



QMC Fall Methods Workshop Series

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2. Confirmatory Factor Analysis (CFA)

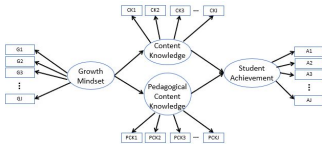


- **Benefits of CFA**
 - Properly model latent variables
 - Assess instrument reliability
 - Assess item quality

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3. SEM = path analysis + CFA



- **Benefits of SEM**
 - Model complex relationships, test nuanced theories
 - Handle measurement error appropriately
 - Improved power and inferential accuracy
 - SEM is foundational for many other methods and techniques

Path Models

A Quantitative Methods Consulting Center Workshop

Ashley Heady, EdM Measurement & Evaluation

About Me - Ashley Hedy

- BS Supply Chain, Information, & Analytics
- MEd Measurement & Evaluation
- 1st year PhD in Quantitative Methodology
- Hobbies - card games, conspiracy theories, & cooking



Agenda

1. Brief Review of Multiple Regression
2. Overview of Path Models
3. Building a Path Model
4. Estimating Path Models using R
 - a. Evaluating & tuning model fit
5. Resources & Extras

Data Example

2014 live birth data from the CDC

1000 observations

11 variables, 5 binary variables

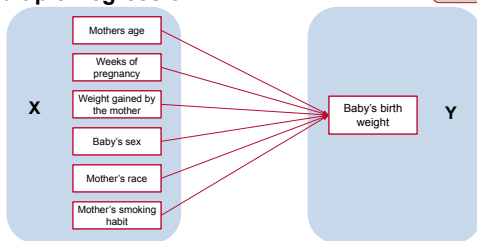
- Fathers age
- Mothers age
- Weeks of pregnancy
- Premature birth status (B)
- Doctor visits during pregnancy
- Weight gained during pregnancy
- Birthweight of the baby
- Baby's sex (B)
- Mothers smoking status (B)
- Mothers marital status (B)
- Mothers race (B)

Multiple Regression

$$\begin{aligned} \text{Baby's birth weight} = & \alpha + \beta_1 \text{ mothers age} + \beta_2 \text{ weeks of pregnancy} \\ & + \beta_3 \text{ weight gained by the mother} \\ & + \beta_4 \text{ baby's sex} + \beta_5 \text{ mothers race} \\ & + \beta_6 \text{ smoking habit} + \varepsilon \end{aligned}$$

Multiple Regression

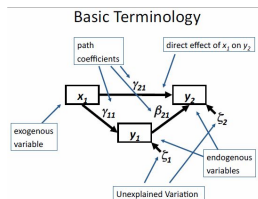
R-squared = 0.33



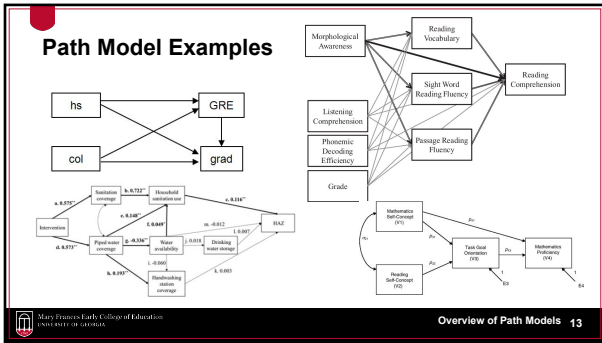
The Basics of Path Analysis

Why do path analysis?

- More complex models than multiple regression
- Y's can predict Y's
- Ability to compare models to find the best fit
- Ability to refine a theorized model
- Understanding path analysis helps understand structural equation modeling (SEM)!



*Streibler, D. L. (2005). Finding Our Way: An Introduction to Path Analysis. The Canadian Journal of Psychiatry, 50(2), 115-122.
<https://doi.org/10.1177/07087437050500207>

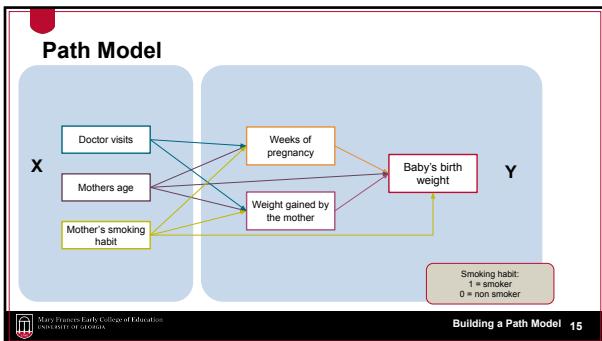


So what are we doing?

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> We're assuming there's an underlying model and relationship between the variables and we're trying to draw that out

> Those relationships are expressed in covariances between our observations



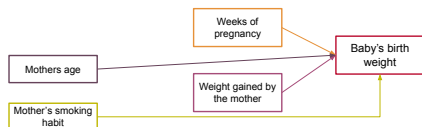
Writing up the path analysis equations

- Baby's birth weight = weeks of pregnancy + weight gained + smoking habit + mothers age
- Mothers weight gain = smoking habit + mothers age + doctor visits
- Weeks of pregnancy = smoking habit + mothers age + doctor visits

Smoking habit:
1 = smoker
0 = non smoker

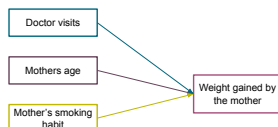
Path Model - Baby's birth weight equation

Baby's birth weight = weeks of pregnancy + weight gained + smoking habit + mothers age



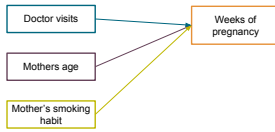
Path Model - Mothers weight gain equation

Mothers weight gain = smoking habit + mothers age + doctor visits



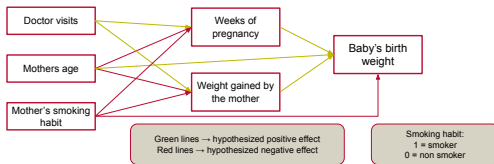
Path Model - Weeks of pregnancy equation

Weeks of pregnancy = smoking habit + mothers age + doctor visits



Before we run the model

- Make some assumptions about how the relationships might work
- Remember any relationships you don't estimate are automatically set to zero
 - Meaning no direct effect!



Estimating Path Models in R

Estimating Path Models in R

- 1 Install lavaan & open the library
- 2 Define the relationships
- 3 Run the model
- 4 Evaluate the fit

The Code

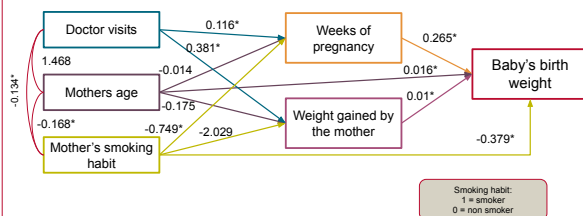
```
install.packages(lavaan); library(lavaan)

model_path <- '
weight ~ weeks + gained + habit_nonsmoker + mage
gained ~ habit_nonsmoker + mage + visits
weeks ~ habit_nonsmoker + mage + visits
visits ~ mage
visits ~ habit_nonsmoker
mage ~ habit_nonsmoker
'

fit <- sem(model_path, data = df)

summary(fit, fit.measures=TRUE, standardized=TRUE)
resid(fit,type='normalized'); modindices(fit)
```

Path Model with Estimates



Model Fit Evaluation

Chi-Squared Null hypothesis is essentially "the model fits" Looking for: - $p\text{-value} > 0.05$	RMSEA Two outputs: > RMSEA estimate > RMSEA Confidence Interval Looking for: - $RMSEA \leq 0.05$	CFI/TLI CFI & TLI compare your proposed model to the baseline model Looking for: - $CFI \text{ \& TLI } \geq 0.90$
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Estimating a Path Model 25

Model Tuning

Residuals > Shows you the difference between your actual covariance matrix and the fitted model covariance Looking for: - Values > 2 are problematic	Modification Indices > Shows you paths and covariances that could be estimated in the model that would make the model fit better Looking for: - Values > 4 → let the model estimate
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Things to remember in path model analysis

- Complex models are hard to interpret & require lots of data! Keep it simple
- Remember to look at all the fit statistics, they come as a package (but remember chi-squared is very sensitive!)
- Your proposed model does not prove causality, it's just an assumption of how things work


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Resources & Extras

Resources for Path Models & SEM

Lavaan Website
lavaan.ugent.be/
tutorials & resources

YouTube
CenterStat,
our QMC YouTube channel

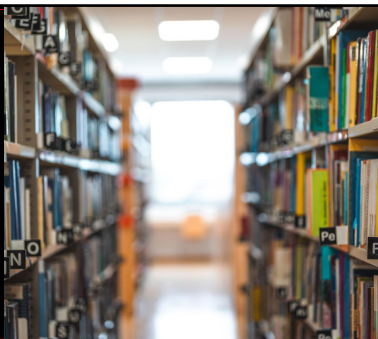
ERSH 8750
Introduction to
Structural Equation
Modeling

ERSH 8130
Survey of
Latent Variable
Models

More Questions?

Visit us at the Quantitative
Methods Consulting Center!

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Thanks for coming!
