Cohort and Content Variability in Value-Added Model School Effects

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Introduction

Value added Models, or VAMs:

Are intended to measure the effect of teachers and/or schools on students' achievement

Establishing the stability (reliability) of the models is prerequisite to establishing validity, which is foundational for their use in high-stakes policy applications

Study purpose

Evaluate the stability of school-level VAM estimates across cohorts and content area.

Cohort effects

VAMs assume estimates do not depend on the specific sample of students modeled.

Typically, only one year of data is included in estimates.

- Estimates may then be representative of policy or implementation effects
- Student mobility is high in many schools

If school effects do depend, in part, on sampling variability, then the validity of estimates is threatened

Content effects

Little research has explicitly explored the difference in school rankings by the content area.

Much research has investigated school effects in a single content area, while ignoring others (Raudenbush and Bryk, 1986; Raudenbush and Willms, 1995)

Should we expect schools to have the same effect across content areas? What does it mean if different effects are observed?

Research Questions

What is the stability of school effect estimates across cohorts and content area (reading and math)?

What proportion of the variance in students' scores is attributable to school, cohort, or content facets?

How does the number of cohorts modeled impact the reliability of school effect estimates?

Methods: Sample

Demographics

	Proportion
nonWhite	35
SWD	12
Female	50
FRL	50

Operational statewide accountability data

Three cohorts of students matched longitudinally across Grades 3-5 (approximately 27000 students per cohort)

727 schools, with an average of 122.44 students per school (SD = 95.17)

Analysis plan

Fit a VAM to each cohort of students in each content area

Explore changes in schools' normative rank across models

Fit a combined model across cohorts

Use Generaliziability Theory to (a) estimate the reliability of school effects, and (b) project reliability, given a change in the number of cohorts modeled.

Basic school-effects model

$$\mathrm{RIT}_{ig} = \hat{} \quad + \check{}\ _1(g4) + \check{}\ _2(\mathrm{Pr} \times g3_4) + \check{}\ _3(\mathrm{Pr} \times g3_5) + \check{}\ _4(\mathrm{P}$$

RIT_{ig}: State test score in Grade g for student i (includes both students' Grade 4 and Grade 5 data)

: Model intercept (mean Grade 5 scores, given average Grade 3 and 4 scores)

$g4$: Dummy code indicating if the outcome was in Grade 4 (rather than Grade 5)

Pr: Students prior state test score

- $g3_4$: Grade 3 prior state test score, Grade 4 outcome
- $g3_5$: Grade 3 prior state test score, Grade 5 outcome
- $g4_5$: Grade 4 prior state test score, Grade 5 outcome

r_i and u_j: Random by-student and by-school variation

$$r_i \sim N(0, \ _{stu})$$

$$u_j \sim N(0, \ _{sch})$$

e_{ij}: Unmodeled residual variance

$$e_{ij} \sim N(0, \ _e)$$

Breaking the model apart

Grade 4 outcome

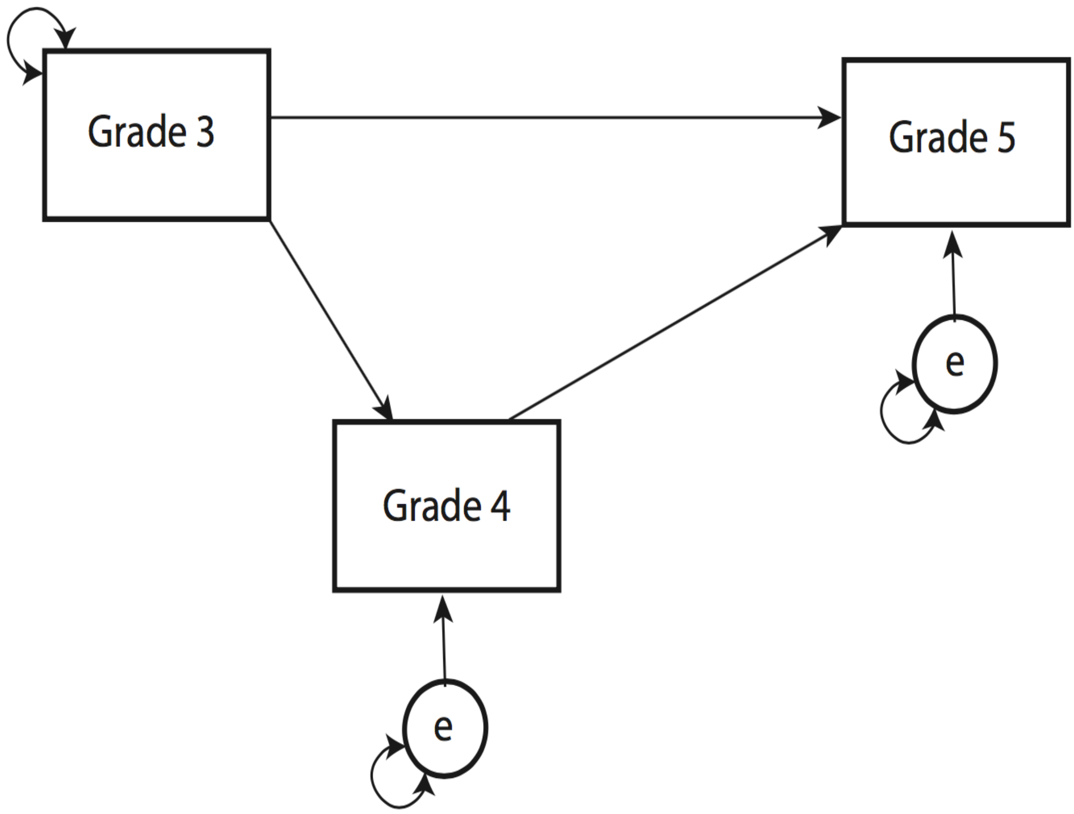
$$RIT_{i4} = \hat{} \ + \breve{} \ _1(g4) + \breve{} \ _2(Pr \times g3_4) + r_i +$$

Grade 5 outcome

$$RIT_{i5} = \hat{} \ + \breve{} \ _3(Pr \times g3_5) + r_i + u_j + e_{ij}$$

$$RIT_{i5} = \hat{} \ + \breve{} \ _4(Pr \times g4_5) + r_i + u_j + e_{ij}$$

Fixed-effects portion of the model



Note the residual variances were constrained to be equal

Combined model

$$(g4) + \breve{\ }_{2}(Pr \times g3_4) + \breve{\ }_{3}(Pr \times g3_5) + \breve{\ }_{4}($$

$$r_i + u_j + v_c + v_c u_j + e_{ij}$$

v_c: Random cohort variation

$$v_c \sim N(0, \ _{coh})$$

$v_c u_j$: Random cohort by school variation (latent interaction variable)

$$v_c u_j \sim N(0, \ _{cohSch})$$

G-Theory

Relative reliability coefficient

$$G = \frac{{}^{2}_{sch}}{{}^{2}_{sch} + \frac{{}^{2}_{cohSch}}{n_{coh}'} + \frac{{}^{2}_{e}}{n_{stu}' n_{coh}'}}$$

Absolute reliability coefficient

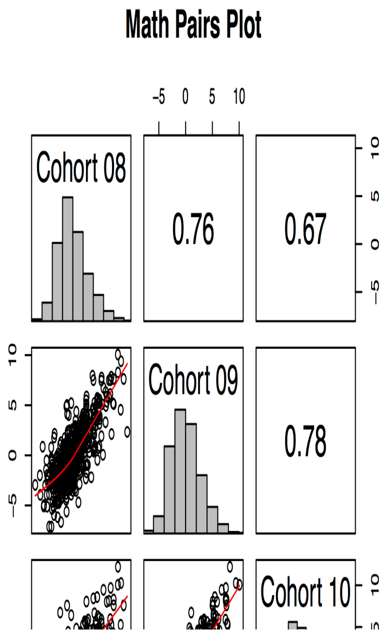
$$\Phi = \frac{{}^{2}_{sch}}{{}^{2}_{sch} + \frac{{}^{2}_{stu}}{n_{stu}'} + \frac{{}^{2}_{coh}}{n_{coh}'} + \frac{{}^{2}_{cohSch}}{n_{coh}'} + \frac{{}^{2}_{e}}{n_{stu}' n_{coh}'}}$$

A priori minimal threshold for reliability: 0.90

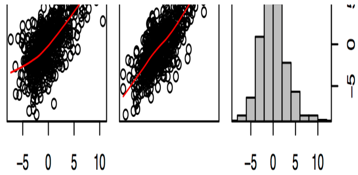
Results: School-effect variability across cohorts (math)

- ~ 33.77% of schools did not change quartiles
- ~ 53.66% changed quartiles at least once
- ~ 12.57% changed quartiles

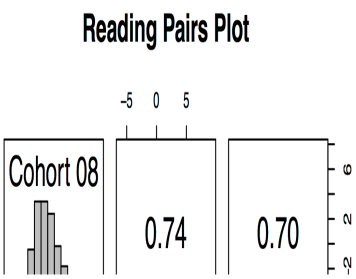
  between each cohort modeled
- ~ 22.7% of schools changed more than one quartile
- ~ 3% of schools moved



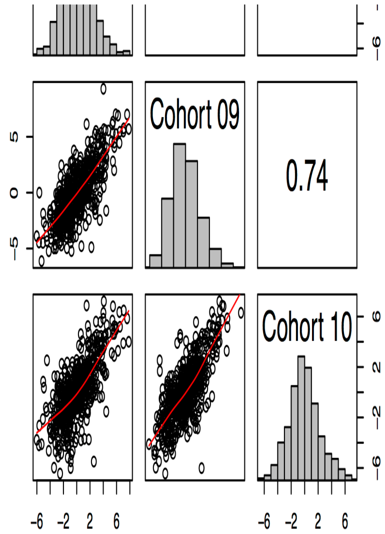
from the bottom to the top quartile, or vice versa, depending on the specific cohort modeled



Results: School-effect variability across cohorts (reading)



- ~ 33.71% of schools did not change quartiles



- ~ 53.11% changed quartiles at least once
- ~ 13.18% changed quartiles between each cohort modeled
- ~ 22.41% of schools

  changed more than one quartile
- ~ 3% of schools moved from the bottom to the top quartile, or vice versa, depending on the specific cohort modeled

Variability across content areas

~ 53%, 55%, and 52% of schools maintained their normative quartile ranking between content areas, for Cohorts 08-10, respectively

~ 36% to 39% of schools changed one quartile

~ 7% to 9% of schools changed two quartiles

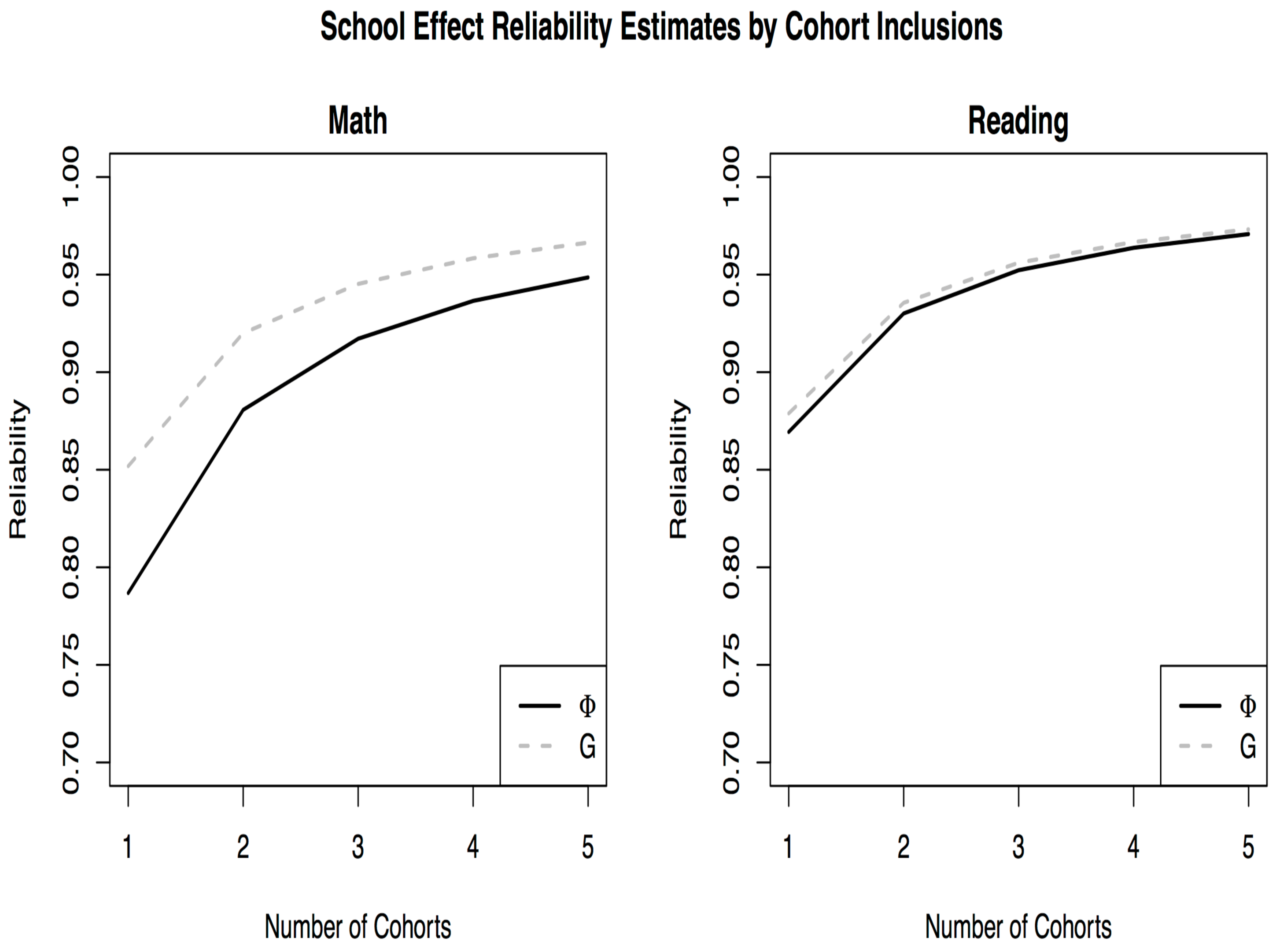
Results: G-Theory

	Variance Components			
	Math	**Percentage**	**Reading**	**Percentage**
$^{2}_{stu}$	55.63	67.5	44.02	68.43
$^{2}_{sch}$	8.68	10.5	6.07	9.44
$^{2}_{coh}$	0.84	1.0	0.08	0.12
$^{2}_{cohSch}$	1.51	1.8	0.84	1.30
$^{2}_{e}$	15.82	19.2	13.32	20.71

$G =$ 0.95 and 0.96 for reading and math, respectively
$\Phi =$ 0.92 and 0.95 for reading and math, respectively

- Majority of variance associated with students, followed by unmodeled variance
- Schools next most important facet
- Cohort and cohort by school variance negligible, relative to the whole

Results: D-Study



Discussion

- VAMs applied in high-stakes policy settings generally assume the estimates are independent of sampling variability.
  - Results of this study suggest high variability depending on the specific cohort of students modeled
- Generally, a single number is used to quantify the school effect
  - Results of this study indicate a more nuanced and multidimensional representation may be more appropriate
- Projected reliability was moderate when a single cohort was modeled
  - Reliability increased dramatically with the inclusion of even one additional cohort

Limitations and future directions

- This study investigated "pure" cohort effects, but annual estimates may be more reflective of how the models are applied in practice.
  - What's the year-to-year stability?
- Unclear the extent to which changes in school ranks were attributable to sampling variability versus "true" changes in school functioning
- School persistence was not modeled directly

Thanks!

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